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Faculty of Business Administration and Management

Smart and Sustainable Mobility: New Trends, Business Models, Technologies and Cases - A Study Strategy.

Master’s Thesis

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Declaration of Originality.

Declaration

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1. Abstract

Abstract: In an increasingly environmentally and mobility – conscious world, this study delves into the analysis of emerging trends, innovative business models, disruptive technologies, and relevant cases in the realm of smart and sustainable mobility. Through a multidisciplinary study strategy, intersections between technology, economics, and environmental sustainability are examined to better understand how these convergences are shaping the future of mobility. Through a theoretical approach, this study provides a comprehensive view of the opportunities and challenges in the field of sustainable mobility, offering crucial insights for designing policies, business strategies, and technological solutions in the pursuit of a cleaner and more efficient future in terms of urban mobility.

Keywords: Smart Mobility; Smart Cities; Sustainable Development; Business Model; Trends; Energy Efficiency, Greenhouse Gases.

Resumen: En un mundo cada vez más consciente de los desafíos medioambientales y de movilidad, el presente estudio se adentra en el análisis de las tendencias emergentes, modelos de negocio innovadores, tecnologías disruptivas y casos relevantes en el ámbito de la movilidad inteligente y sostenible. Mediante una estrategia de estudio multidisciplinaria, se examinan las intersecciones entre la tecnología, la economía y la sostenibilidad ambiental para comprender mejor cómo estas convergencias están dando forma al futuro de la movilidad. A través de un enfoque teórico y práctico, este estudio proporciona una visión integral de las oportunidades y desafíos en el campo de la movilidad sostenible, ofreciendo insights cruciales para diseñar políticas, estrategias empresariales y soluciones tecnológicas efectivas en la búsqueda de un futuro más limpio y eficiente en términos de movilidad urbana.

Palabras Clave: Movilidad Inteligente; Ciudades Inteligentes; Desarrollo Sostenible; Modelo de Negocio; Tendencias; Eficiencia Energética, Gases de Efecto Invernadero.

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2. Introduction.

The global landscape of urban mobility is undergoing a profound transformation. Rapid advancements in technology, coupled with an increasing awareness of environmental sustainability, have led to the emergence of smart and sustainable mobility solutions. In a world where cities are expanding and population densities are rising, traditional transportation systems are being challenged to meet the demands of modern society. Congestion, pollution, and inefficient use of resources have placed immense pressure on urban environments, prompting governments, businesses, and communities to seek innovative solutions that enhance mobility while minimizing environmental impact.

This study presents a comprehensive analysis of emerging trends, innovative business models, disruptive technologies, and relevant case studies within the smart and sustainable mobility domain. The central focus is on understanding how these forces intersect to shape the future of urban transportation. By combining theoretical exploration with real-world examples, this study aims to provide a holistic understanding of the challenges and opportunities in smart mobility. The goal is to explore how new technologies and business strategies can be leveraged to create more efficient, equitable, and environmentally friendly transportation systems.

In the first chapter, the study outlines the theoretical framework of smart and sustainable mobility, focusing on key concepts such as smart cities, the role of information and communication technologies (ICTs), and the integration of artificial intelligence (AI) and the Internet of Things (IoT). The framework delves into how these technological advancements drive the evolution of mobility, fostering greater energy efficiency, reducing greenhouse gas emissions, and enhancing the overall quality of urban life. By reviewing the environmental and social implications of smart mobility, the chapter sets the stage for understanding its multifaceted nature.

The second chapter shifts attention to the current state of smart mobility, offering a comparative analysis of successful case studies from around the world. It investigates how cities like London, Paris, and companies like Zipcar and Uber have implemented smart mobility solutions to address their unique challenges. These examples highlight various approaches to funding, resource management, and the integration of new mobility services into existing urban infrastructures. The cases further underscore the importance of innovative business models and partnerships in driving smart mobility forward.

The future trends shaping the mobility industry form the crux of the third chapter. The study explores the growth of electric vehicle (EV) infrastructure, autonomous vehicles (AVs), and advanced air mobility (AAM) solutions such as electric vertical take – off and landing (eVTOL) aircraft. These technologies are poised to revolutionize urban mobility by providing cleaner, more efficient alternatives to conventional transportation systems. The chapter also examines the technical, regulatory, and societal challenges that must be addressed to ensure the successful deployment of these technologies. As cities grapple with the need to reduce their carbon footprints while meeting the mobility needs of their citizens, the integration of EVs, AVs, and AAMs offers promising avenues for sustainable development.

In the concluding chapter, the study synthesizes the key findings and offers recommendations for stakeholders seeking to adopt smart and sustainable mobility solutions. The research reveals that while technological innovations such as electrification, automation, and digitalization are critical, their effectiveness depends on the integration of supportive governance frameworks, business models, and infrastructure. The study concludes that smart mobility has the potential to not only enhance the efficiency of urban transportation but also significantly reduce its environmental impact, thus contributing to broader global sustainability goals.

This research provides valuable insights for policymakers, urban planners, and business leaders as they navigate the complexities of modern mobility. By embracing the convergence of technology and sustainability, cities can create more liveable, efficient, and resilient environments that meet the evolving needs of their citizens. The findings emphasize that a collaborative effort between the public and private sectors is essential to achieve the full potential of smart and sustainable mobility solutions.

3. Objectives.

3.1. General Objectives.

1. To comprehensively investigate the intersection of smart technologies and sustainable practices within the realm of urban mobility, by:
2. To provide insights into the implementation strategies and impacts of smart and sustainable mobility solutions on urban transportation systems, through:

3.2. Specific Objectives.

1. Reviewing and analysing current literature and research on smart mobility technologies and sustainable transportation practices.
2. Identifying and evaluating the effectiveness of various smart mobility technologies, such as IoT, AI, and electrification, in promoting sustainable urban transportation.
3. Assessing the socio-economic and environmental implications of smart and sustainable mobility initiatives, including their potential to reduce greenhouse gas emissions and alleviate traffic congestion.
4. Examining different business models and policy frameworks that support the development and implementation of smart and sustainable mobility solutions.
5. Investigating case studies of successful smart mobility projects and initiatives in diverse urban settings, highlighting best practices and lessons learned.

3.3. Research Questions.

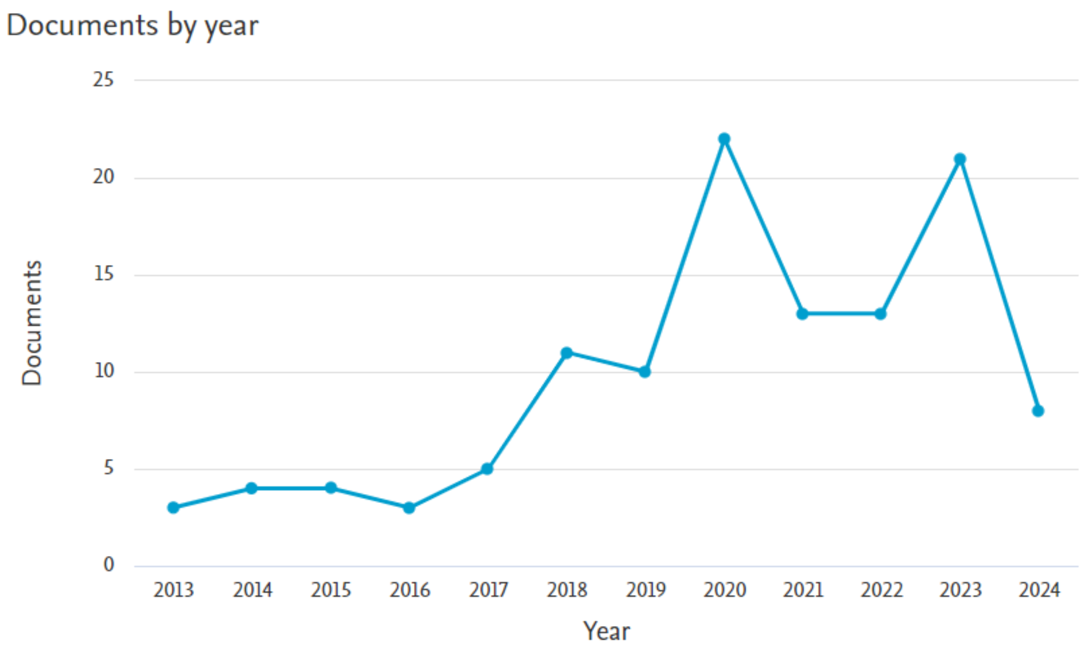
- How do various smart mobility technologies, such as IoT, AI, and electrification, contribute to the sustainability of urban transportation systems?
- What are the key challenges and barriers to the widespread adoption of smart and sustainable mobility solutions, and how can policymakers and industry stakeholders effectively address these obstacles?

4. Methodology.

Before going through all the concepts' definition, literature research was conducted in order to retrieve relevant information about the topic. The databases from which the studies were scoped were "*Scopus*", and Polytechnic University of Valencia's (UPV) institutional repository for academic, scientific, and corporate research "*RiuNet*". The search query consisted of using keywords that were included in documents' titles and abstracts. The Scopus search included the next keywords: (smart AND sustainability AND mobility AND business) AND PUBYEAR > 2012 AND PUBYEAR < 2025 which were then filtered by publication year, showing only studies published between the years 2013 and 2024. From the 117 results, 24 sources were finally retrieved accordingly to the study's topic (**Annex II**). In order to enrich the literature review, 22 external sources were consulted as well, specifically used to provide first hand data and information about the cases and future trends analysed in this study.

Afterwards, a brief literature analysis was conducted in order to understand the evolution of research published in Scopus during the past ten years and by country published, and to determine which terms where used the most by publisher. **Figure 1** plots an important increase in the number of articles, research and studies published in the already mentioned literature database, showing the rising concern about improving cities urban mobility by using emerging technologies and sustainable practices. Going through each year, between 2013 and 2017 only three to five documents were published each year, while between 2018 and 2023 the number of publications started to increase steeply, quadrupling the previous numbers.

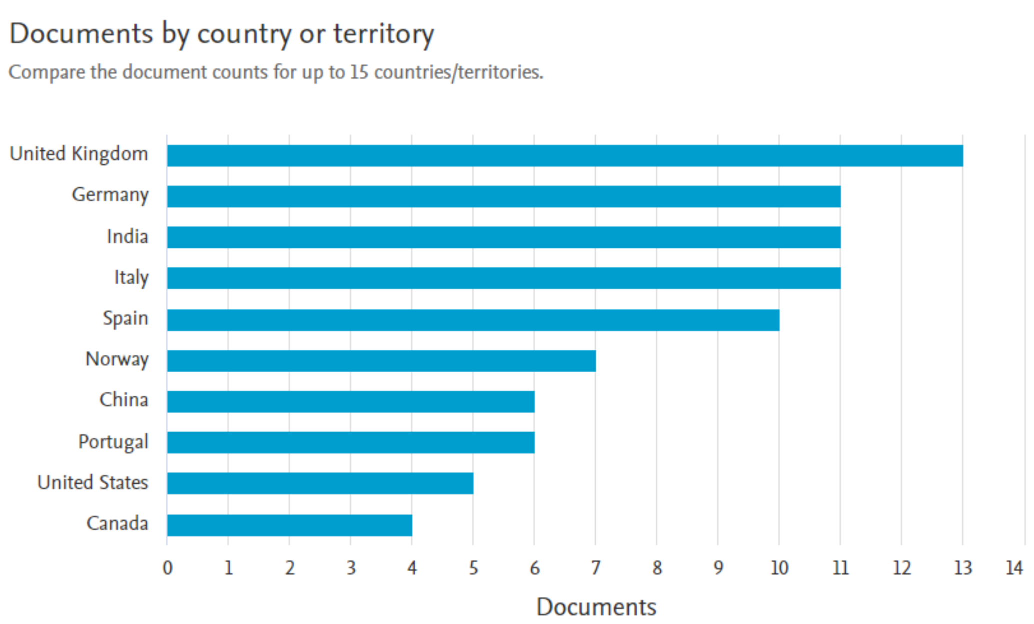
Figure 1: Amount of research documents published between 2013 – 2024 in Scopus.



Source: Own made.

Moreover, it was considered appropriate to provide specific information regarding the key countries and regions that lead the research scope within this field. **Figure 2** shows that UK's institutions have published the largest amount of research papers related with the study case, followed by Germany's, India's, and Italy's.

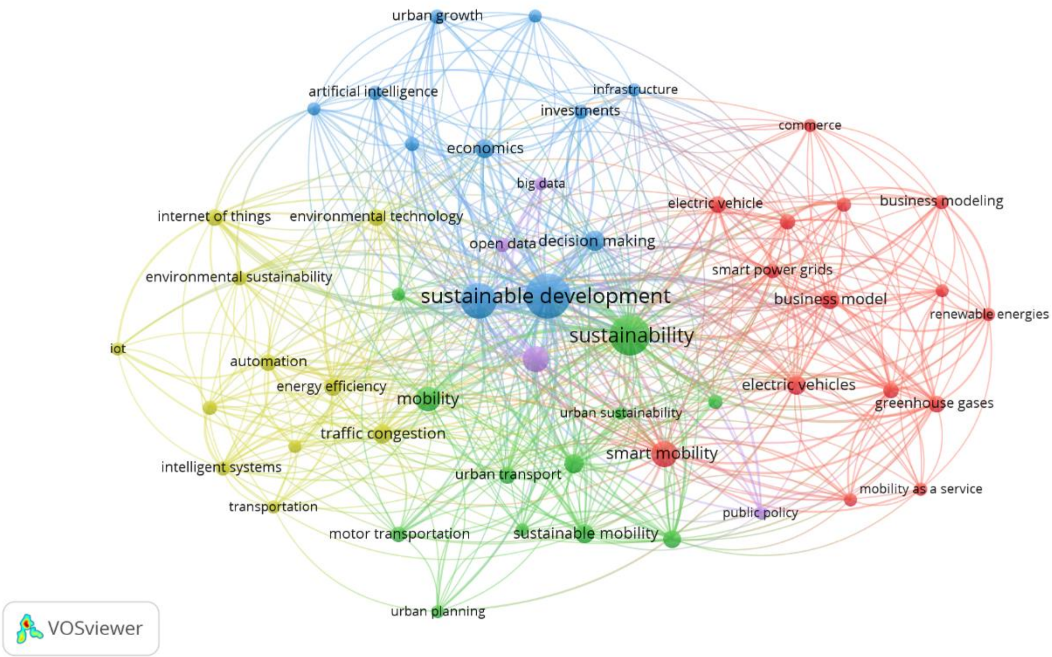
Figure 2: Amount of research documents published by country or territory.



Source: Own made.

In order to have a clearer understanding of the areas where the research was conducted, a network co – occurrence map was drawn in assistance with VosViewer software. **Figure 3** presents the network visualization of co – occurring terms in the broadened group of 117 articles. These terms are grouped in clusters portrayed in different colours, connected by link strength that counts the amount of publication in which a pair of terms co – occur.

Figure 3: Papers analysis by terms co – occurrence for the set of 117 articles.



Source: Own made.

5. Theoretical Framework.

5.1. Smart City.

The concept of the smart city has been acknowledged as essential for addressing urban challenges in Europe and worldwide. However, coming up with a holistic definition of smart city is challenging due to its constantly evolving nature, and the lack of distinction from other, related city labels, such as "*Green City*", "*Intelligent City*" or "*Digital City*" (Warnecke et al., 2019). The term smart city first emerged in the 1990s in the United States, initially referring to the pivotal role of Information and Communication Technologies (ICTs), hardware, algorithms, and data management in enhancing city life quality in urban areas and achieving economic excellence. This idea originated as a solution to the rapid urbanization problems and as a strategy for sustainable development (Matwiejczyk & Snarska, 2023).

Despite use of ICTs has been considered as the "core" of smart city development, the existence of these technologies alone does not necessarily imply intelligent or smart urban development (Warnecke et al., 2019). Nowadays, there is an increasing focus on local community participation and their contributions to city development, meaning a smart city is viewed as one where investments in human and social capital, coupled with both traditional and modern ICT infrastructure, drive sustainable economic growth and enhance quality of life through efficient resource management and participatory governance. Over time, smart city concepts have developed in five key areas: technology, institutions, innovation, people, and place (Matwiejczyk & Snarska, 2023).

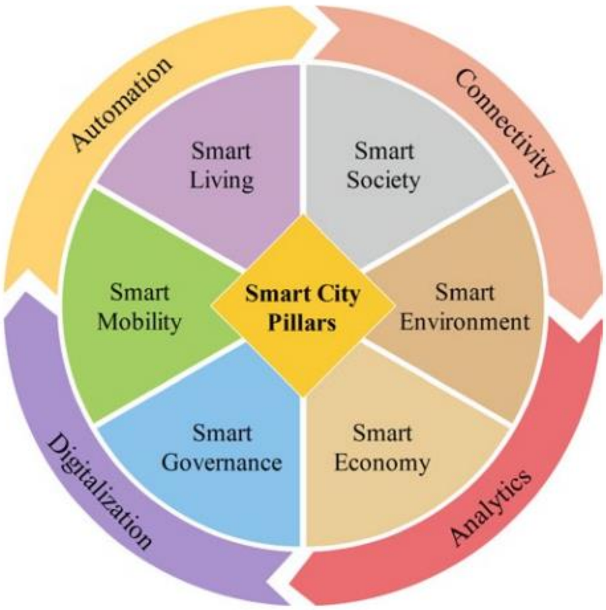
According to Matwiejczyk & Snarska (2023), the European Parliament, in its "Mapping Smart Cities in the EU" initiative, supports the idea of a smart city as one that addresses public issues through ICT, founded on partnerships among various municipalities. The smart city's functionality is enabled by leveraging technology to gain competitive advantages and create a network of people, businesses, technology, infrastructure, usage, energy, and space with future – oriented solutions.

A smart city is typically characterized by six interlinked dimensions:

- A competitive economy (**smart economy**) that is highly efficient and technologically advanced, utilizing ICT to develop services, products, and new business models.
- Integrated transport networks (**smart mobility**) that include comprehensive transport and logistics systems.

- Sustainable resource management (**smart environment**), where smart cities efficiently use natural resources, increase renewable energy use, and optimize financial and environmental operational costs.
- High-quality social capital (**smart people**), where technologies empower residents to act effectively and solve urban issues, with educated citizens using innovative communication channels for interaction with local administration.
- High quality of life (**smart living**), ensuring a safe and healthy environment with broad access to ICT infrastructure to support various lifestyles, behaviors, and consumption patterns.
- Effective public management (**smart governance**), characterized by public participation in decision-making, transparency, and high-quality, accessible public services.

Figure 4: Smart City Pillars.



Source: (Khamis, 2021)

Having considered the dimensions that define what a smart city is, this paper reckons the definition mentioned by (Wawer, Grzesiuk, & Jegorow, 2022) on their research: *"Smart Mobility in a Smart City in the Context of Generation Z Sustainability, Use of ICT, and Participation."*, which states:

“A city can be defined as ‘smart’ when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory governance.”

5.2. Smart Mobility.

5.2.1. Definition and Concept.

As mentioned before, smart mobility is one of the six dimensions of smart cities, and it plays an especially relevant building block. However, similarly with smart city’s concept, develop a consensual definition on smart mobility is a challenge, since the requirements and needs of each community varies depending on the context they live. One common definition of smart mobility is “a set of coordinated actions addressed at improving the efficiency, effectiveness and the environmental sustainability in cities,” which is characterized by transport and the use of ICTs (Lorenz et al., 2023). According to Mitieka, Luke, Twinomurinzi, & Mageto, (2023), smart mobility also seeks the integration of distinctive transportation modes, including walking, cycling, public transport, and private vehicles, alongside the incorporation of emerging technologies, integrated planning strategies, and personalised transportation services to deliver seamless, sustainable, reliable, and accessible transportation solutions.

To put it in other words, smart mobility consists of local accessibility, (inter-)national accessibility, availability of ICT infrastructure, and sustainable, innovative and safe transport systems, that contribute to the future of city planning and logistics by fulfilling the Sustainable Development Goals defined by the United Nations (Lorenz, Madeja, & Leyh, 2023).

5.2.2. Environmental and Social Implications.

In 2015, the United Nations introduced 17 Sustainable Development Goals (SDGs) to address the urgent need for transformative change towards sustainability. These goals define sustainability as meeting present needs without compromising the ability of future generations to meet their own, encompassing environmental, social, and economic dimensions. The SDGs consist of 169 targets and are monitored by 231 unique indicators, with a collective aim for global achievement by 2030, reflecting a universal commitment from all 191 UN member nations.

These goals provide a critical foundation for the progress towards smart mobility, which involves integrating traffic-related technologies and smart services into urban environments. Smart mobility is not just about technology; it also requires balancing technological advancements with the needs of citizens, as emphasized by sustainability factors. Recent studies show significant potential for analysing the contribution of smart cities to sustainable development, with some researchers arguing that cities cannot truly be smart without being sustainable. This highlights the essential role of sustainability in smart city initiatives. Furthermore, research into the adoption of information and communication technology (ICT) for sustainable development within various industries reinforces the connection between ICT and sustainability (Lorenz et al., 2023).

Khamis (2021) states that smart mobility plays a fundamental role in achieving SDGs through initiatives such as the Sustainable Mobility for All (Sum4All), established in 2017, and hosted by the World Bank. The objective of this international cooperation is to bring together public organizations and private companies to take action in sustainable transport and mobility issues worldwide and help implement SDGs accordingly (World Bank Group, 2019). To do so, SuM4All developed the Global Tracking Framework (GTF) which, alongside the Global Mobility Report, provides critical information and tools that serve as a core for measuring the progress toward sustainable mobility by complementing the goals and indicators stablished in the SDGs, and informing transport policy and investment decisions. The Global Mobility Report identified 2 core goals that are directly related to mobility. SDG 3 aims for Good Health and Well – Being, specifically with target 3.6 which focuses on reducing global deaths and injuries from traffic accidents. On another hand, SDG 11 is about Sustainable Cities and Communities, with target 11.2 that focuses on providing access to safe, affordable, accessible, and sustainable transport systems for all.

However, Hussain et al. (2023) developed a framework based on several smart mobility – related KPIs categorised within different dimensions (economic, social, and environmental sustainability, and technology), alongside the set of SDGs that each indicator is aligned to (**See Annex III**). The framework showcase that among indicators, SDG 3, SDG 4, SDG 5, SDG 7, SDG 8, SDG 9, SDG 10, SDG 11, SDG 12, SDG 13, SDG 14, SDG 15, SDG 17 are connected to these, with **SDG 3, SDG 8, SDG 9, SDG 11, SDG 12**, and **SDG 13** being the most representative and relevant.

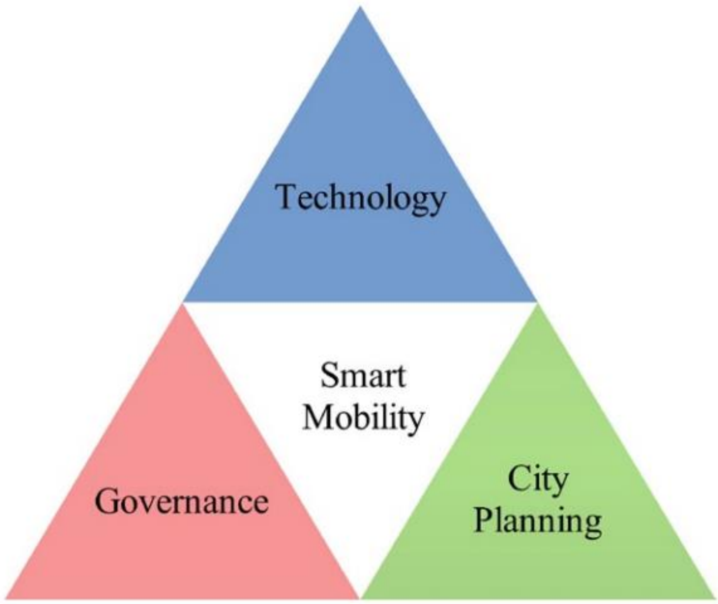
Additionally, Lorenz et al. (2023) on their study on assessing a framework for the sustainability impact of ITS in smart cities, found that smart mobility has an impact on SDG 6, SDG 7, and SDG 16.

Altogether, the integration of smart mobility within the framework of the 17 SDGs is crucial for achieving environmental, social, and economical sustainability. The SDGs, which aim to address environmental, social, and economic dimensions of sustainability by 2030, provide a robust foundation for developing smart mobility solutions. Research underscores the essential role of sustainability in smart city initiatives, highlighting how ICT and smart mobility contribute to the broader goals of sustainable development. Initiatives like Sustainable Mobility for All (SuM4All) further support this by offering tools and frameworks to track progress and inform policy decisions, following four fundamental goals, namely, **safety** (drastically minimize fatalities, injuries, and crashes), **green mobility** (downgrade the environmental footprint of mobility), **universal access** (connect all people and communities), and **efficiency** (optimize the predictability, reliability, and cost effectiveness of mobility). Various studies and frameworks have identified multiple SDGs that are directly and indirectly impacted by smart mobility, emphasizing the comprehensive role of smart mobility in advancing global sustainability efforts (Khamis, 2021).

5.2.3. Smart Mobility Triad.

It is a fact that mobility constitutes a human right and a basic need and foundation of social, economic, and cultural exchanges of people, businesses, and societies. The future of mobility is poised to be transformative, prioritizing people, leveraging advanced software, and promoting connectivity and electrification with the ambition to enhance urban living, improve road safety, and foster sustainable practices. Existing evidence suggests that advanced software algorithms have facilitated assisted driving, automated driving vehicles, shared mobility services, Mobility-as-a-Service (MaaS), Mobility on-demand (MOD), and seamless integration of transportation systems (SIMS). Nevertheless, the extended deployment of these technological solutions, such as automated driving vehicles, and their social acceptance might be a challenge. For this reason, smart mobility not only depends on the technology readiness level, but also a well – developed governance strategy, and a strategic city planning (**See Figure 5**). These three components constitute the smart mobility triad, and they must be in poise and complement to each other (Khamis, 2021).

Figure 5: Smart Mobility Triad.



Source: (Khamis, 2021)

5.2.3.1. Smart Mobility Governance.

Developing a well – defined and comprehensive governance framework for smart mobility is a complex task, it must integrate both current and emerging technologies while promoting innovation and managing societal and environmental risks. A holistic approach is needed when developing smart mobility regulations, involving multiple stakeholders in the decision – making process including policymakers, manufacturers, service providers, private sector actors, citizens and users (drivers, cyclists, public transport drivers, ridesharing users, and so on), since each one might have different perspective, and none can fully grasp the entire situation alone (Khamis, 2021).

Regarding legal and regulatory frameworks for smart mobility technologies, especially for automated driving systems, data privacy, and liability, are still underdeveloped in terms of safety verification. Consequently, established standards such as ISO 26262 and Safety of the Intended Functionality (SOTIF or ISO/PAS 21448) address some of these issues by employing tools such as FMEA to prevent potential risks on a process, or by providing guidance on design, validation, and verification measures to mitigate limitations on sensors, algorithms, and actuators (Khamis, 2021).

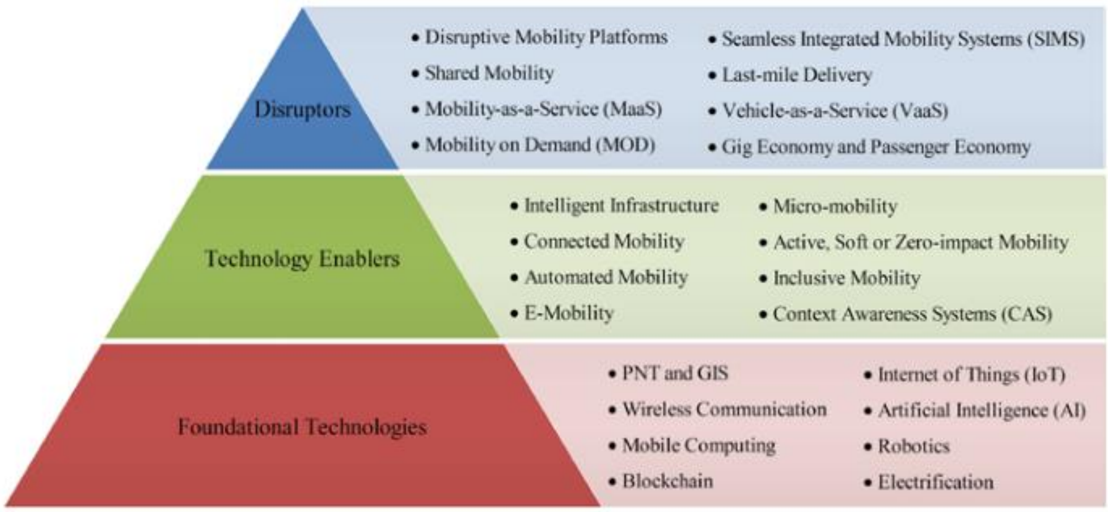
5.2.3.2. City Planning.

Smart mobility systems promise to revolutionize urban planning, akin to the impact of early automobiles. This transformation will include redesigning transport corridors for pedestrians and cyclists, creating bicycle highways, and setting up emergency spots for autonomous vehicles. An enhanced city infrastructure will offer real-time traffic updates and integrate connected mobility technologies. Visible and digital road signage will support automated driving, while new pedestrian crosswalks and speed management measures will improve safety. The implementation of smart parking, micromobility stations, extensive EV charging infrastructure, and air taxi hubs will further modernize urban mobility. Lastly, bridge design standards will be updated to accommodate heavy truck platooning (Khamis, 2021).

5.2.3.3. Technologies Driving Smart Mobility.

With technology as its core, smart mobility services and systems, such as MaaS and SIMS, brought the neo – liberalization of people and goods transportation, revolutionising the whole industry. Defining the whole technological framework that gave birth to these solutions might be a little complex considering the vast amount of existing hardware and software tools that keep changing through time. For this reason, Khamis (2021), categorised the technological elements involved in smart mobility into 3 groups, as illustrated in **Figure 6**.

Figure 6: Smart Mobility: Foundational Technologies, Technology Enablers, and Disruptors.



Source: (Khamis, 2021)

5.2.3.3.1. Foundational Technologies.

As its name clearly indicates, these technologies are smart mobility’s axioms for the development of relevant and innovative products and services. Some examples of these are:

PNT and GIS.

Positioning, **Navigation**, and **Timing** (**PNT**), according to Khamis (2021), is defined as a combination of three different components:

- **Positioning:** the capability to determine one's exact location and orientation in two or three dimensions, based on a standard geodetic system like the World Geodetic System 1984, or better called WGS84.
- **Navigation:** is the capacity to identify current and target positions (relative or absolute) and adjust course, orientation, and speed to reach a desired location globally, from subsurface to space.
- **Timing:** is the ability to obtain and maintain precise time from a standard like UTC, anywhere globally, within user-defined time parameters, including time transfer.

When PNT is utilized with map data and other information (weather or traffic data) the outcome is the most popular and recognized service, the Global Positioning System (GPS) (U.S. Department of Transportation, 2017), which use satellite signals to determine the absolute position (longitude, latitude, and altitude) of a person or vehicles on Earth (Khamis, 2021).

Geographic Information System (**GIS**) allows the input, storage, manipulation, and output of geographical information. This information system plays a pivotal role in existing and emerging mobility systems, by providing free access to satellite images, aerial photographs, and topographic data for much of the Earth's surface. Some examples include Google Earth, Google Maps, Bing Maps, HERE WeGo, MAPS.ME, and many more.

Wireless Communication.

Wireless communication enables the reliable transmission and exchange of real-time data, ensuring seamless integration between mobility platforms and their surroundings (Khamis, 2021). Communication technologies enabled the interconnectivity between mobility systems which allowed vehicles become communication centres, allowing them to connect with everything (V2X). The core technologies used for smart mobility are:

- **Dedicated Short-Range Communications** (**DSRCs**): based on IEEE 802.11p, this technology allows continuous, low-latency, and secure data exchanges vehicle – to – vehicle (V2V) and vehicle – to – everything (V2X).
- **Cellular V2X** (**C-V2X**): it utilizes single-carrier frequency division multiple access (SCFDMA) in the physical layer to achieve higher data rates and longer ranges than DSRC.

- **Hybrid Architecture:** Combining DSRC and cellular technology into a hybrid solution is promising because it leverages the strengths of both. For example, if V2V multihop communication fails due to fragmented data transmission, cellular technology can serve as a backup to relay information. Additionally, vehicles can reconnect to the Internet via cellular networks if they lose connection with Roadside Units (RSUs) (Khamis, 2021).

Mobile Computing.

Mobile computing encompasses the information technologies, products, services, and operational strategies that allow authorized users and mobile assets to access data, information, and computing resources from any location. It serves as a foundational technology enabling different innovative mobility services, including app-based ride-sharing companies, Anything-as-a-Service (XaaS), Mobility-as-a-Service (MaaS), Vehicle-as-a-Service (VaaS), click-and-collect last-mile delivery services, and mobile cloud sensing. Depending on the proximity of data sources, storage, and computational units, mobile computing can be divided into three categories (Khamis, 2021):

Mobile Cloud Computing (MCC) it is a powerful technology that utilizes flexible resources of various private and public clouds, along with network technologies, to provide unlimited functionality, storage, and mobility. It supports numerous mobile devices anytime and anywhere, through Ethernet or Internet connections, regardless of differing environments and platforms, based on a pay-as-you-use basis (Khamis, 2021).

On the other hand, **Mobile Fog Computing (MFC)** and **Mobile Edge Computing (MEC)** are two emerging approaches designed to address issues in cloud computing such as latency, bandwidth, privacy, and security. These paradigms bring computation and storage closer to where the data is generated, allowing mobile users and platforms to offload some or all of their computation-intensive and time-sensitive tasks to nearby or local servers. This proximity results in ultra-low latency, better bandwidth utilization, faster insights and actions, and higher scalability by reducing the amount of data sent to centralized data centres or the cloud, and instead performing computations on the fog or edge. Additionally, MFC and MEC enhance privacy and security, which is particularly beneficial for smart mobility.

Blockchain.

Blockchain is a Distributed Ledger Technology (DLT), based on a peer – to – peer network that creates a reliable, secure and transparent environment, enabling data to be stored globally across thousands of servers and facilitating easy access to this information. Essentially, blockchain is a decentralized database or public ledger that records all transactions or digital events executed and shared among participating parties (Khamis, 2021).

Table 1 illustrates how blockchain technologies are classified, namely, public permissioned (e.g., Sovrin and IPDB), public permissionless (e.g., Bitcoin, Ethereum, and IOTA), private permissioned (e.g., Hyperledger Fabric, Hyperledger Sawtooth, Hyperledger Iroha, R3 Corda, and CULedger), private permissionless (e.g., Hyperledger Sawtooth in a permissionless mode). Assets in blockchain technologies can be categorised as hard assets (physical property, homes, cars), and intangible assets (votes, ideas, reputation, intention, health data, information, etc.) (Khamis, 2021).

Table 1: Types of Blockchains.

		Access to Transaction Validation	
		Permissioned	Permissionless
Access to transactions	Public	All participants can read and submit transactions, but only authorized ones can validate transactions.	Every participant in the network can both read, submit, and validate transactions
	Private	Only authorized participants can read, submit, and validate transactions	Not Possible

Source: own made by data collected from (Karger, Jagals , & Ahlemann, 2021)

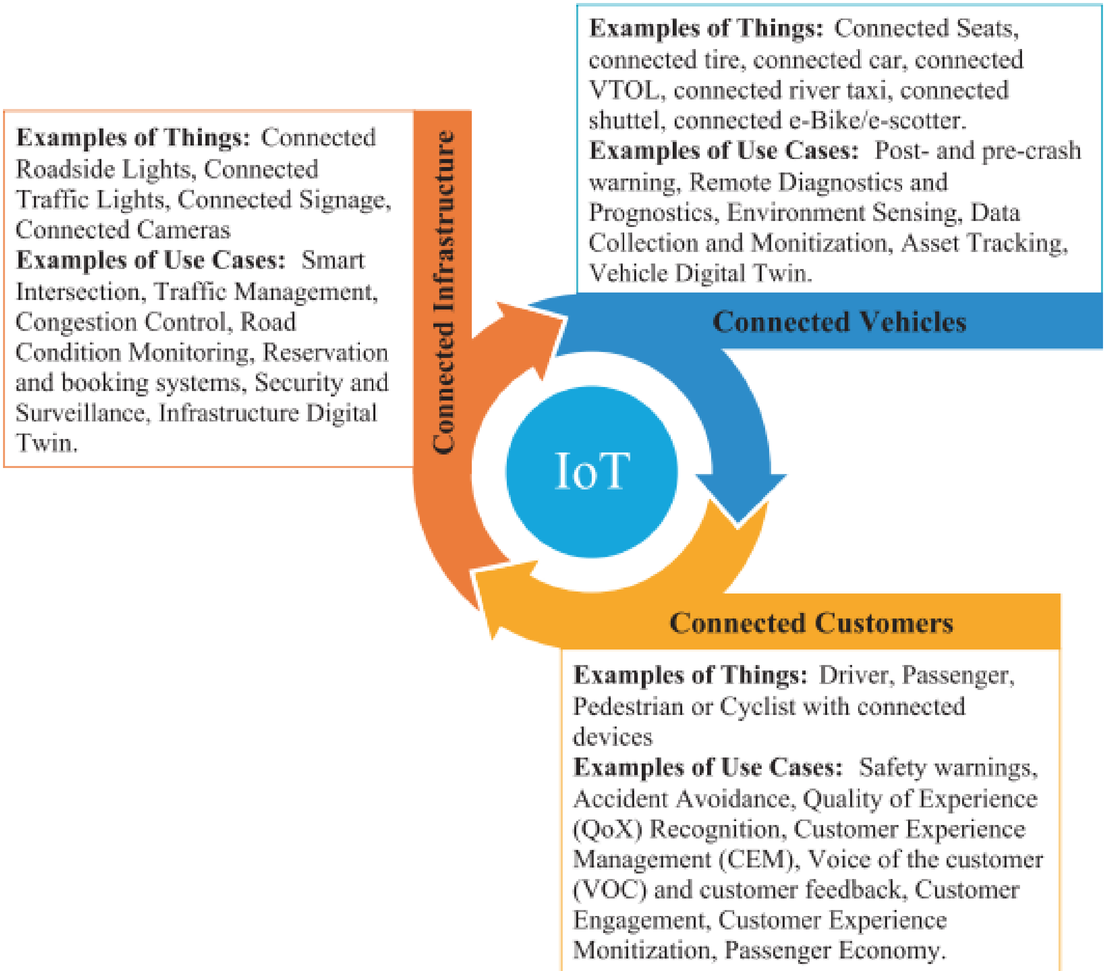
Putting it into context, blockchains can revolutionize transportation and logistics industry by enabling services like authentication, access control, secure and fast payments without a central authority, and seamless information sharing. It can empower users with relevant information about mobility services, allow monitoring processes, and trace the origins of goods. For example, a person boards a bus equipped with blockchain and IoT technologies. As the person gets in, the crypto-spatial layer records their embarkation and disembarkation points, automatically deducts the fare from their digital wallet, and credits it to the transport company's wallet.

Internet of Things.

The Internet of Things (IoT) connects any device to the Internet and allows devices to communicate with each other for data sharing and operational control. Expanding on this, the Internet of Everything (IoE) brings together people, processes, data, and things to create intelligent and valuable network connections. According to Cisco, IoE transforms data into actions that generate new capabilities, enhanced experiences, and significant economic opportunities for businesses, individuals, and countries. The true value of IoT/IoE lies not in making individual devices smart but in enabling seamless processes across multiple systems (Khamis, 2021).

In context of smart mobility, a "thing" can refer to various entities, such as a driver, passenger, commuter, transit operator, pedestrian, or cyclist with any connected device capable of being assigned an IP address and transferring data over a network. Among the applications in smart mobility, they include condition monitoring, predictive maintenance or remote diagnostics and prognostics, vehicle tracking, geo-fencing, traffic management and congestion control systems, fleet management, reservation and booking systems, and security and surveillance. **Figure 7** shows some examples of connected "things" and use cases that include this technology.

Figure 7: IoT examples and use cases.



Source: (Khamis, 2021)

Artificial Intelligence (AI).

Evolution of AI has successfully introduced numerous commercial products and services that have impacted in people's daily lives. This technology aims to replicate, enhance, and understand human intelligence to create systems and processes that can operate and interact independently in various environments, whether they are structured or unstructured, static or dynamic, and fully or partially observable. This involves integrating human-like abilities such as situational awareness, decision-making, problem-solving, learning from the environment, and adapting to changes. AI includes various subfields like perception (object recognition, image understanding, speech recognition, speech synthesis, and natural language understanding), knowledge representation, cognitive reasoning, machine learning, and data analytics (descriptive, predictive, diagnostic, and prescriptive analytics). It also involves problem-solving techniques (such as constraint satisfaction and optimization), distributed AI, and action-oriented technologies (such as virtual assistants and robots) (Khamis, 2021).

As a foundational technology, AI has been driving both current and emerging mobility systems and services. Some important applications of AI in smart mobility are:

- Creating innovative features, services, or business models to enhance customer experience, outperform competitors, and reach underserved markets.
- Automatically collecting relevant data to generate insights for better decision-making.
- Identifying and utilizing "dark data" that mobility companies have but do not currently use.
- Developing situational awareness to perceive and understand elements in the environment and predict their future status. This includes vehicle diagnostics, detecting and understanding Vulnerable Road Users (VRUs), recognizing user behaviour, and predictive infotainment.
- Enabling Advanced Driver Assistance Systems (ADASs) and automated driving tasks such as perception, planning, control, learning, and adaptation in dynamic environments.
- Supporting digital transformation initiatives like generative design, test automation, over-the-air updates, robotic process automation, intelligent agent assistants, digital twins, dispatch and routing optimization, fleet management, and digital go-to-market tools.

Robotics.

Robotics is the engineering discipline and technology focused on robots, encompassing their design, manufacturing, control, and programming. It involves using robots to address problems, studying control processes, sensors, and algorithms found in humans, animals, and machines, and applying these control processes to robot design. Essentially, robotics connects perception (interpreting sensory information) to planning (deciding actions).

In context of smart mobility, robotics is considered a crucial foundational technology, since it has been the precursor of numerous innovations projects, like robo taxis, robotic chauffeurs, aerial taxis, autonomous river taxis, automated people movers, delivery drones, self-driving shuttles, and walking assistance exoskeletons have emerged from robotics research.

Electrification.

Due to the increasing concern of Greenhouse Gas (GHG) emissions within transportation industry, specially of CO2 emissions produced from different transportation systems, electrification became a global trend to help mitigate the impact on the environment by decarbonize transportation, replacing fossil fuels with electricity in passenger and freight vehicles. However, this trend is nothing but new. Historically, both hydrogen and electric technologies predate the combustion engine, with innovations like Humphry Davy's fuel cell principle in 1801 and William Grive's gas battery in 1839, or General Motors' first mass-produced electric vehicle, the EV1, that paved the way for these technologies (Khamis, 2021).

In the context of Electric Vehicles (EVs), these vehicles can be categorised in various forms depending on their powertrain options into battery-electric vehicles (BEVs) and fuel cell vehicles (FCVs or FCEVs) (Khamis, 2021).

Hydrogen fuel cells offer faster refuelling and longer driving ranges in comparison with full electric vehicles. However, recent improvements in battery and charging technology, such as GM’s Ultium energy options, have significantly enhanced EV capabilities, offering ranges up to 650 km and quick acceleration, not to mention the high costs of hydrogen production, thus higher prices on hydrogen – based fuel cells. Additionally, fast chargers and inductive charging pads are making EV charging quicker and more convenient. Battery swapping, particularly for shared mobility services, is also gaining traction, with companies like Ample introducing modular battery systems (Khamis (2021); Hassan et al. (2023)).

Despite the benefits of EVs, there is debate about their environmental impact. Although EVs produce no emissions on the road, the manufacturing process, particularly of batteries, is not entirely green. To ensure EVs are fully zero-emission, their electricity must come from renewable sources, and battery production must be CO2 neutral. This requires optimized production processes, reduced reliance on materials like cobalt and lithium, increased use of recycled materials, and improved battery recycling methods. Currently, the recycling rate of lithium – ion batteries in the EU and the U.S. is less than 5% (Khamis, 2021).

5.2.3.3.2. Technology Enablers.

Technology enablers offer opportunities to enhance current processes and develop new, sometimes disruptive, business models and services. In the realm of smart mobility, these technologies encompass intelligent infrastructure, connected mobility, automated mobility, e-mobility, micromobility, active/soft mobility, inclusive mobility, and Context Awareness Systems (CAS) (Khamis, 2021).

Intelligent Infrastructure.

Mobility infrastructure is crucial for supporting both current and emerging personal and shared mobility systems and for effectively managing these systems. This infrastructure includes intelligent transportation systems (ITS), smart intersections, high-quality cycling infrastructure like cycle highways, smart parking, charging infrastructure, and smart pavement. This section will only focus on ITS due to its extensive research and its adoption by the United Nations and European Parliament (Khamis, 2021).

ITS encompasses all technical solutions and construction concepts related to traffic. According to the United Nations Economic Commission for Europe (UNECE), ITS consists of "a set of procedures, systems, and devices that improve the mobility of people and transportation of goods by collecting, communicating, processing, and distributing information, and obtaining feedback to quantify results." The European Parliament describes ITS more broadly as communication systems that provide services for various transport modes and traffic management, supporting safer, more coordinated, and smarter use of transport networks. Despite varying definitions, all share the goal of technology-based, data-driven traffic management to enhance mobility. ITS employs numerous tools based on information and communication technology, supporting smart mobility concepts. Specific applications include traffic light control systems and analytical tools for transport management (Lorenz et al. 2023).

Different perspectives on ITS focus on varying means and needs:

Strategy and Activity Perspective:

Defined by the U.S. Department of Transportation, this perspective outlines ITS strategies and related activities. Depending on the source, 16 to 26 activities are defined, including (Lorenz, Madeja, & Leyh, 2023):

- **Traffic management and operations:** e.g., traffic surveillance, signal control, speed, and intersection warning systems, enhancements for bicycle and pedestrian crossings.
- **Road weather management operations:** e.g., road weather information systems, winter roadway operations.

- **Maintenance and construction management:** e.g., coordination for construction management, work zone management.
- **Incident and energy management:** e.g., emergency management, emergency vehicle routing.
- **Public transportation management:** e.g., electronic fare collection, multimodal travel connections, transit surveillance.

Functional Perspective:

This perspective focuses on ITS functions like management or information provision, including (Lorenz et al. 2023):

- Traffic management.
- Public transport management.
- Cargo transport and fleet management.
- Traffic safety management and regulation monitoring.
- Road incident and emergency services management.
- Traveler information services and electronic payment services.
- Electronic toll collection systems.

Requirements Perspective:

This perspective emphasizes requirements profiles and specific technical systems, again overlapping with strategic and functional perspectives. Relevant systems include (Lorenz et al. 2023):

- Advanced Traffic Management Systems (ATMS).
- Advanced Traveler Information Systems (ATIS).
- Advanced Vehicle Control Systems (AVCS).
- Commercial Vehicle Operations (CVO).
- Advanced Public Transportation Systems (APTS).
- Rural Transportation Systems (ARTS).
- Automated and Autonomous Driving.
- Intelligent Traffic Data (Smart Traffic).
- Vehicle Networks (Connected Vehicles).

Modality Perspective:

The modal split is crucial for sustainable solutions, although this perspective does not present activities or strategies. This perspective categorizes ITS according to transport modes, including (Lorenz et al. 2023):

- Car traffic.
- Public transport (bus, train, city train, subway).
- (E-)bike.
- Motorcycle.
- Plane.
- Vessel.

Connected Mobility.

Connected mobility fosters data-rich environments and supports a variety of applications and services aimed at making roads safer, reducing congestion, and enhancing eco-friendliness. It enables features such as real – time navigation, traffic information, safety alerts, accident prevention, advanced driver assistance systems (ADAS), and automated driving systems (ADS). For instance, these features can warn you of a car in your blind spot before changing lanes, alert you to hazards like obstacles, pedestrians, or icy roads, provide remote diagnostics, give real-time traffic updates, help locate parking or charging stations, and facilitate online shopping (Khamis, 2021).

The broad concept vehicle – to – anything (V2X) ensures seamless information sharing between vehicles and their environment in the right format at the right time, extending to any mobility platform, including cars, trucks, bikes, e-scooters, air/river taxis, and automated people movers (Khamis, 2021). V2X types include:

- **Vehicle – to – Occupant (V2O):** enables features like phone-as-a-key, in-vehicle connectivity for work and entertainment, driving error recognition, and customer connectedness through WiFi, 4G, and 5G.
- **Vehicle – to – Vulnerable Road User (V2VRU):** enhances detection and localization of pedestrians, cyclists, motorcyclists, and people with disabilities, recognizing their crossing intentions and motion behaviour.
- **Vehicle – to – Vehicle (V2V):** improves safety and traffic flow with applications like crash warnings, lane change alerts, and coordinated vehicle movement.
- **Vehicle – to – Environment (V2E):** monitors and reports on road and environmental conditions, such as traffic signs, road quality, and weather-related hazards, contributing to improved road safety and maintenance.
- **Vehicle – to – Infrastructure (V2I):** provides services like road condition alerts, SOS assistance, work zone warnings, emergency vehicle signal pre – emption, pedestrian detection, and traffic condition monitoring, improving overall traffic management and safety.

- **Vehicle – to – Network (V2N):** facilitates warnings for disabled vehicles, security management, multimodal mobility systems, real-time traffic monitoring, and enhanced in-cabin consumer experiences to build brand loyalty.

Automated Mobility.

According to UITP Advancing Public Transport (2024), automated mobility involves advanced technologies like connectivity, automation, and AI into vehicle fleets to improve their safety, efficiency, and sustainability.

Regarding Automated Driving Systems (ADSs), they are defined by the Society of Automotive Engineers (SAE) International as the hardware and software that can continuously perform the entire dynamic driving task (DDT), even if it is restricted to a particular operational design domain (ODD) (ISO/SAE International, 2021). On the contrary, Driving Automation System is a more generic term that refers to the hardware and software capable of performing either part or all the DDT (ISO/SAE International, 2021). To better understand what these terms mean, the SAE developed a taxonomy of six exclusive levels:

- **Level 0 – No Automation:** the driver performs the entire DDT, meaning all real-time operational and tactical tasks necessary to drive a vehicle in on-road traffic, excluding strategic tasks like trip planning and choosing destinations and waypoints.
- **Level 1 – Driver Assistance:** the driving automation system, while engaged, performs part of the DDT by executing either longitudinal (accelerating and braking) or lateral (steering) tasks, but not simultaneously. The driver is expected to perform the remainder tasks of the vehicle, including disengaging the driving automation system when required.
- **Level 2 – Partial Driving Automation:** similar to level 1, but in this case the driving automation system can execute both longitudinal and lateral tasks, with the driver expected to perform the remainder tasks.
- **Level 3 – Conditional Driving Automation:** while engaged, the ADS performs the entire DDT within the limits of its operating conditions (ODD). The system also determines whether its ODD limits are about to be exceeded, or if there is a system failure, addressing a request for the driver to intervene in the vehicle’s motion. The driver may disengage the ADS when required.
- **Level 4 – High Driving Automation:** similar to level 3, with the main difference that the ADS is capable to automatically perform a DDT fallback (response of the driver/in – vehicle user to intervene the DTT or achieve a minimal risk condition) and achieving a minimal risk condition when needed (e.g. due to a

DDT performance – relevant system failure or ODD exit, if applicable). The driver may request the ADS to disengage and resume the vehicle's motion control.

- **Level 5 – Full Driving Automation:** at this level, there is a sustained and unconditional performance by the ADS of the entire DDT and DDT fallback. The driver may also request the ADS to disengage and resume the vehicle's motion control.

In the smart mobility context, automated driving is not only focused on cars, but also to a variety of mobility platforms for people transportation and delivery of goods, for example, self – driving shuttles (e.g., GM's Cruise Origin), self – driving modular stores (e.g., Toyota's e-Palette), last mile delivery (e.g., Starship, Nuro, and Robby), and first- and middle-mile delivery self-driving trucks (e.g., Embark, Tesla, TuSimple, Daimler Trucks, Waymo, Plus.ai, and Peloton) (Khamis, 2021).

E – mobility.

Just as it was mentioned before, electrification of vehicles aims to reduce the GHG emissions produced by Internal Combustion Engine (ICE) vehicles, having severe negative impacts on the environment. Electric mobility, also known as e – Mobility, offers eco-friendly transportation solutions that reduce CO2 emissions and noise pollution on roads thanks to the electric – based engines. It encompasses any transportation platform driven by electric motors, such as electric cars, bikes, scooters, skateboards, wheelchairs, eVTOLs, electric shuttles and commuters, automated people movers (APMs), hyperloop systems, monorails, and more (Khamis, 2021).

While e-mobility is rapidly gaining traction and social acceptance, particularly in micromobility and public transit, several obstacles persist, especially in the realm of electric cars. These challenges include the higher cost of electric cars compared to internal combustion engine (ICE) vehicles, insufficient incentives for purchasing EVs, concerns about driving range, battery life and degradation, and the availability and interoperability of supercharging stations (Khamis, 2021).

Micromobility.

Micromobility refers to small, lightweight, and low-speed (under 25 km/h) vehicles typically used for short trips. It is increasingly popular and includes and includes electric versions of conventional mobility platforms, such as, bikes, scooters, skateboards, and self-balancing unicycles. Among these electric versions, known as electric micromobility platforms, encompass e-bikes, speed pedal-assist bicycles, e-scooters, electric seated scooters (Vespa-style or mopeds), e-skateboards, electric motorcycles (E2Ws), fun utility vehicles (FUVs), e-rickshaws, Segways, and electric quadricycles/battery – powered mini cars (Khamis, 2021).

These platforms can be either shared or personally owned and serve various purposes such as local transportation, first-mile (home to transport system) and last-mile (transport system to final destination) connectivity, surveillance, and delivery services in places like campuses, residential areas, shopping malls, theme parks, and airports. Micromobility's affordability makes it appealing in both developed and developing countries, where transportation costs are a significant household expense (Khamis, 2021).

Active, Soft, or Zero-Impact Mobility.

Despite the beneficial impacts that the previously mentioned electric micromobility platforms bring to society and the environment, the truth is that their non – motorised human – powered counterpart (including walking) are also a fun, cheap, and environmentally friendly means of transport, not to mention the positive impacts they bring to people’s health and well – being (Khamis, 2021).

Many cities worldwide are encouraging active mobility through various initiatives. For example, Brussels Mobility initiated a poster campaign called #BlijvenTrappen ("keep pedalling") and temporarily provided free access to the city's Villo shared bicycle program, attracting 7,000 new subscribers (Khamis, 2021).

Inclusive Mobility.

The World Health Organization (WHO) estimates that 1.1 billion people, or 14.1% of the global population, live with some form of disability. This group is the largest minority worldwide and the only one that anyone can join at any time. Additionally, most individuals are likely to face mobility impairments at some stage in their lives. This, combined with population aging on the rise driven by declining fertility rates and increased life expectancy, people’s transportation options often diminish. For instance, by 2050, over 35% of Italy's population will be above the age of 85 (Khamis, 2021).

For this reason, inclusive mobility aims to support the movement of elderly and physically challenged individuals, aligning with the US Department of Transportation's (USDOT) concept of the "Complete Trip." This concept involves a seamless journey from origin to destination, regardless of the number of modes, transfers, or connections. The success of a complete trip is measured by a person’s ability to travel reliably, spontaneously, confidently, independently, safely, and efficiently without interruptions in the travel chain, irrespective of location, income, or disability. Various governmental and nongovernmental organizations are focusing on inclusive mobility and working on related policies and legislation. For example, the USDOT’s Accessible Transportation Technologies Research Initiative (ATTRI) is spearheading efforts to develop and implement innovative applications to enhance mobility options for all travellers, especially those with disabilities (Khamis, 2021).

Context Awareness Systems (CAS).

Context Awareness Systems (CAS) are systems that collect and analyse contextual information from various sensors to understand the environment and adapt accordingly. This includes identifying entities, their relationships, and predicting future states based on current data. Contextual information addresses situation-related questions such as who, what, when, and where, characterizing the working environment and system agents (e.g., mobility platforms like connected vehicles, bikes, or shuttle buses, and human agents such as drivers, passengers, and connected pedestrians) based on location, identity, activity, time, and status. Contexts are categorized into explicit context and implicit context. Explicit context includes directly observable parameters (pedestrian status, battery status, traffic lights status, car location, and so on), meanwhile implicit context involves all those parameters that are not directly or easily perceived (Quality of Experience). Quality of Experience (QoE or QoX) can be defined as the extent of satisfaction or dissatisfaction experienced by a user of an application or service, based on how well their expectations regarding the utility and/or enjoyment of the application or service are met, considering the user's personality and needs (Khamis, 2021).

Incorporating contextual information can inspire new services like info mobility/geo-marketing, loyalty program promotions based on location, and other vehicular cloud services. It can also help adapt connectivity based on available bandwidth or other Quality of Service (QoS) parameters (Khamis, 2021).

5.2.3.3.3. Disruptors.

Disruptive innovation is the process where new competitors challenge established firms, often despite having fewer resources. This can occur in two ways: new entrants might focus on neglected market segments with a product deemed inferior by the incumbent's most demanding customers and gradually improve to move up-market, or they might create entirely new markets, converting non-consumers into consumers. It is important to mention that disruption involves not just technology, but a combination of technological advancements and innovative business models (Hopp, Antons, Kaminski, & Salge, 2018). Disruptors significantly change consumer behaviour, industries, and business operations, leading to revolutionary products and services that initially serve low-end or unserved consumers and eventually enter the mainstream market, always aiming to meet future customer needs (Khamis, 2021).

Putting this into smart mobility’s context, disruptors are typically not groundbreaking innovations but fundamentally change how mobility service providers function, how people travel, and how goods are transported (Khamis, 2021). In order to maintain the coherence among the technologies driving smart mobility, this section will be focused on this framework rather than innovative business models derived from these technologies. For this matter, the next section will be discussing the business models involved in smart mobility.

Autonomous Ground Vehicles.

Autonomous vehicles are those that can do all of their functions independently and self – sufficiently (self – governance). Although the system's objectives are set by another entity, it operates autonomously in achieving these goals, making simple but independent decisions (ISO/SAE International, 2021; Khamis, 2021).

Various concepts for autonomous ground vehicles have been proposed and tested to support Mobility-as-a-Service, mobility on demand, and seamless integrated mobility in urban areas, airports, malls, hospitals, and theme parks. These concepts include self-driving shuttles (SDSs), smart carts, smart wheelchairs, and autonomous robot valets. Self-driving shuttles (SDSs), which can navigate autonomously at speeds below 50 km/h, offer an appealing and flexible shared mobility solution for first-/last-mile transportation and last-mile delivery (Khamis, 2021).

3D Mobility and Urban Air Mobility (UAM).

Dimensions in mobility’s context refers to the degree of freedom (DOM) mobility platforms have in a two – dimensional space (streets). Trams, street cars, and trains are considered 1-DOF mobility platforms as they primarily move longitudinally. Cars, on the other hand, have 2-DOF, allowing for both lateral and longitudinal movement. Transitioning to 3D mobility marks a shift from constrained two-dimensional street travel to three-dimensional mobility spaces (adding the air as third dimension), enabling 3 – DOF movement (lateral, longitudinal, and vertical) or more accurately, 6-DOF movement (lateral, longitudinal, vertical, roll, pitch, and yaw) when considering rotational movements (Khamis, 2021).

In this context, urban air mobility (UAM) represents rapidly developing urban transport systems for people and cargo. Air taxis, flying taxis, and flying cars are innovative and disruptive mobility platforms based on an on-demand aviation model. These VTOL (Vertical Take – off and Landing) aircraft can be customized for different passenger capacities or cargo transport. eVTOLs (electric VTOLs) use electric propulsion to navigate densely populated urban areas at speeds up to 320 km/hr with a range of about 200 miles (Khamis, 2021). Some examples of these revolutionary vehicles include uberAIR, Uber Elevate, Airbus Flying Taxi, FlyNow, Boeing Flying Taxi, and Cadillac eVTOLs (Khamis, 2021).

River Taxis.

River taxis, water taxis, or water buses have been offering urban public or private transportation for centuries in numerous cities with abundant waterways, such as Venice, Bangkok, Tokyo, New York, Sydney, and Toronto, to facilitate quick point-to-point travel and alleviate traffic congestion (Khamis, 2021). Before long, new technologies such as automation will bring innovative solutions into the urban water transportation industry. Autonomous hybrid/electric vessels will be used to transport goods and people in coastal and riverside cities, contributing to traffic decongestion on roads and railways. Ocean Space Drones 1 and 2 are a good example of experimental autonomous boats built by the Norwegian company Kongsberg Maritime (Khamis, 2021).

Automated People Movers (APMs).

According to Lutzemberger et al. (2017) and Khamis (2021), an automated people mover (APM) is an autonomous/driverless, elevated, and advanced fixed guideway transportation system typically used in urban and suburban areas, providing high-frequency and reliable point-to-point passenger service. Traditional APMs use wheel-on-rail/route systems and rotating electrical machines for propulsion. However, applying magnetic levitation (MAGLEV) technology in this field is promising for enhancing performance and reducing costs. These systems employ electric drive bogies within guideway tubes to propel suspended passenger cabins, which can be customized in size, ranging from personal pods to multi-passenger pods, at speeds surpassing 160 km/h (Khamis, 2021).

Hyperloop and Urbanloop.

Hyperloop is a disruptive technology that consists of a sealed vacuum tube with low pressure, through which a floating pod or capsule travels with minimal air resistance or friction, reaching speeds up to 1200 km/h. Some solutions like Hyperloop Transportation Technologies (HTT), Hyperloop One, AECOM, Hardt, and TransPod have introduced the idea in the market, envisioning the low energy and installation costs in comparison with subways and tramways, plus low CO2 emissions. However, due to the lack of real hyperloop systems or testbeds that carry out a complete analysis on energy efficiency, it is still unclear whether this disruptive technology brings low energy costs (Khamis, 2021).

Another novel and disruptive technology for urban transportation is the urbanloop, first introduced in France in 2018 as a rapid travel mobility system. It mainly consists of transparent capsules inspired by one- or two-person sports cars travel within tubes that can be buried, partially buried, or elevated, depending on urban constraints. (Khamis, 2021). French company Urbanloop has been working since 2019 on introducing this innovative technology to the market.

5.2.3.4. Smart Mobility Business Models.

Having explored the various technologies that underpin smart mobility, let’s now turn the attention to the business models that drive its implementation and growth. The previous section delved into the technological advancements such as IoT, AI, automated and autonomous vehicles, and intelligent connected infrastructure (ITS), all of which collectively enhance the efficiency, safety, and sustainability of urban transportation systems. These innovations, while pivotal, require robust and adaptable business models to be commercially viable and widely adopted.

This section aims to dissect the diverse business models that have emerged in the smart mobility landscape, examining how they leverage technological advancements to create value for both users and providers. This section will also discuss some example companies that operate within these business models, exploring the shift from traditional ownership models to shared and service-based frameworks, analysing the economic and environmental benefits of these new paradigms.

Shared Mobility.

There is no universally agreed – upon definition of the “sharing economy”, also known as “collaborative consumption”, or “connected consumption”. One way to describe the sharing economy is as "the practice of transforming unused or underutilized assets owned by individuals into productive resources” (Santos, 2018).

Taking this into consideration, shared mobility, or mobility within the sharing economy, is also a flexible concept that encompasses various emerging models. The rise of commercially available services like car sharing, bike sharing, scooter sharing, ridesharing, ridehailing/ridesourcing, and demand-responsive transit (DRT) had demonstrated the rapid advances of mobility technologies in recent years (Khamis, 2021). What all these new mobility services have in common are two key characteristics: the sharing of an asset (such as a vehicle) rather than owning it, and the reliance on technology, specifically a digital platform (Santos, 2018).

Among the shared mobility services the following are included:

- **Vehicle Sharing Services:** services where multiple customers use the same vehicle at different times. Companies like Zipcar, SHARE NOW, Getaround, Capital Bikeshare, Lime, VeoRide, and Bird (Khamis, 2021).
- **Peer-to-Peer (P2P) Vehicle Sharing Services:** These emerging services allow vehicle owners to rent out their vehicles, when not in use, to others in their area

for short periods of time through a company acting as a broker, similar to platforms like Airbnb and Couchsurfing. The vehicles used in these services can include cars (e.g., Drive Drive Car), bikes (e.g., Spinlister), scooters, Personal Intelligent City Accessible Vehicles (PICAV), VTOLs, SeaBubbles, or other personal transporters (Khamis, 2021; Santos, 2018).

- **Demand-Responsive Transit (DRT), Dial-a-Ride, or Paratransit:** DRT offers pre-booked, shared mobility services that blend public and private transportation, providing an experience related to on-demand mobility. It serves as a middle ground between private vehicles and traditional public transport, often using dedicated small buses, minibuses, or maxi-taxis that respond to user requests made through a phone or smartphone app (Khamis, 2021).
- **Microtransit:** Defined by the US Department of Transportation (USDOT) as a privately owned and operated shared transportation system, micro transit offers both fixed and flexible routes, as well as on-demand scheduling, typically using vans and buses. It is a subset of DRT, with examples including Ford TransLoc, DemandTrans, and Transdev (Khamis, 2021).
- **Ridesharing Services:** Modernized carpooling services like Zimride, Getaround, and Waze Carpool match drivers who are already traveling from point A to point B with passengers using the same service, allowing them to share commuting costs. This concept has historical roots, dating back to World War II when the US government promoted carpooling to conserve resources (Khamis, 2021).
- **Ridehailing or Ridesourcing Services:** Offered by transportation network companies (TNCs) such as Uber, Lyft, and DiDi, these services involve a driver using their personal vehicle to provide on-demand, private trips to paying passengers. The service is facilitated through an app provided by the company, which also manages payments and takes a percentage of the earnings (Khamis, 2021; Santos, 2018).
- **Ride splitting Services:** Provided by TNCs like UberPool and Lyft Line, ride splitting is a hybrid model that combines elements of ride sourcing and micro transit. Drivers use their personal vehicles to professionally transport multiple independent passengers simultaneously on routes that adjust dynamically based on new trip requests. This service differs from ride hailing, mainly because a single passenger can specify pick – up and drop – off locations and preferred travel times (Khamis, 2021; Santos, 2018).

Mobility – as – a – Service (MaaS).

Mobility-as-a-Service (MaaS) constitutes a transformative shift in how mobility is provided and utilized, moving away from the traditional model of personal vehicle ownership towards a shared, integrated, and user-centric approach. It further combines various transportation modes such as public transit, bike – sharing, car – sharing, and ride hailing into a single, unified service accessible through a digital platform (Bokolo, 2023). Instead of owning a car or relying solely on one form of transit, MaaS integrates multiple transportation services into a single accessible platform, typically a mobile app. This platform allows users to plan, book, and pay for different forms of transport such as buses, trains, car rentals, bike shares, and more, all in one place. The goal is to provide a seamless, user-centric mobility solution that adapts to individual needs (Khamis, 2021).

A key feature of MaaS is its ability to integrate payment and infrastructure elements such as parking and vehicle charging. This integration creates an attractive value proposition for customers by offering creative pricing and bundled mobility packages. For example, MaaS platforms can offer different bundles tailored to specific user groups—professionals might get a package including public transport and premium parking, while students might have a bundle with unlimited bike sharing and limited car sharing (Khamis, 2021).

MaaS represents a transformative approach to achieving sustainable mobility in urban environments. By reducing reliance on private vehicles, promoting eco-friendly transport options, and integrating various modes of transport into a single, efficient system, MaaS can significantly contribute to the environmental, economic, and social sustainability of cities (Bokolo, 2023). Some good examples of MaaS are mobile apps like Whim (Helsinki), UbiGo (Gothenburg), Qixxit (Germany), Beeline (Singapore), and Moovit (Khamis, 2021). MaaS represents a transformative approach to achieving sustainable mobility in urban environments by reducing reliance on private vehicles, promoting eco-friendly transport options, and integrating various modes of transport into a single, efficient system, significantly contributing to the environmental, economic, and social sustainability of cities.

Mobility on Demand (MOD).

Mobility on Demand (MOD) is an innovative transportation concept defined by the U.S. Department of Transportation. It allows consumers to access mobility services, goods, and other services on demand through various transportation modes. These include shared mobility, courier services, aerial vehicles, and public transportation solutions.

Key passenger services like trip planning, booking, real – time information, and fare payment are integrated into a single user interface (Khamis, 2021).

MOD providers facilitate access to different mobility modes such as car sharing, bike sharing, scooter sharing, ridesharing, ridehailing, micromobility, shuttle services, public transportation, and other emerging transportation solutions. The primary focus of MOD is on commodifying passenger mobility and goods delivery, along with managing the transportation system. This is distinct from Mobility as a Service (MaaS), which primarily aggregates passenger mobility and subscription services (Khamis, 2021).

MOD systems are designed to respond to customer demands efficiently, considering both the user's and the operator's perspectives. From the user's perspective, the system should minimize trip time and cost while maximizing convenience and experience. From the operator's perspective, it's essential to optimize vehicle distribution, minimize the number of vehicles while maximizing the number of customers served, and optimize vehicle routes. Additionally, pricing strategies are crucial in influencing traveller choices and managing demand. Dynamic pricing, for instance, is a widely studied area in shared mobility, impacting both costs to users and system latency, which are critical for the success of MOD systems (Khamis, 2021).

Seamless Integrated Mobility Systems (SIMS).

Seamless Integrated Mobility Systems (SIMS) represent a sophisticated smart mobility business model designed to enhance the efficiency and sustainability of urban transportation. These systems integrate various physical assets like vehicles and infrastructure with digital technologies and governance frameworks to create a cohesive "system of systems." The core of SIMS is a digital platform that manages all aspects of the transportation environment, including traffic conditions, infrastructure status, and dynamic routing. This platform supports services like dynamic pricing, seamless billing, and intermodal transport management, enabling a user-centric approach that adapts in real-time to changing conditions and user demands (Khamis, 2021).

SIMS aim to handle up to 30% more traffic and reduce travel times by 10% by optimizing resource use and minimizing delays, contributing to sustainable urban development goals. Governance in SIMS includes regulatory and operational standards that ensure safety, privacy, and efficiency across all transportation modes. By merging physical and digital components, SIMS offer a streamlined, efficient, and accessible mobility experience, making urban transport systems more adaptable, less congested, and environmentally friendly. This integration not only improves mobility but also enhances the living standards within urban environments by reducing emissions and supporting smarter city initiatives (Khamis, 2021).

Last – Mile Delivery.

The term "last mile" in supply chain management and transportation planning refers to the final stage of moving people and goods from a transportation hub to their ultimate destination. Specifically, last – mile delivery involves transporting goods from a warehouse or distribution centre to the final delivery point, typically located about 11 miles or 17 kilometres away. The broader supply chain also includes first-mile delivery, which deals with moving goods from manufacturing facilities to distribution hubs, and middle-mile delivery, which covers the transport of goods from these hubs to warehouses (Khamis, 2021).

While last-mile delivery has always been a part of logistics, evolving customer expectations around speed, flexibility, and transparency have transformed this process. Companies like Uber and Amazon have set new standards for these expectations, requiring last – mile delivery systems to adopt new technologies that offer faster, more flexible, and transparent services. Modern last-mile delivery should leverage advanced digital platforms to provide customers with (Khamis, 2021):

- Flexible delivery options, including various timelines like same-day or next-day delivery, with or without additional charges.
- The ability to schedule or reschedule deliveries.
- Options to select or change pickup locations, such as home delivery, click-and-collect points, smart lockers, pickup and drop-off points (PUDO), curbsides, or dark stores, which are traditional retail spaces converted into local fulfilment centres, especially useful during pandemics.

Additionally, customers should have visibility and transparency throughout the process, including delay notifications, communication with dispatchers or delivery personnel, and detailed information about the delivery item to enhance their engagement and overall experience (Khamis, 2021).

For suppliers, additional services could include dynamic order orchestration, delivery route planning, optimal resource deployment, adaptive routing, and fleet management to enhance efficiency and adaptability in the last-mile delivery process (Khamis, 2021).

Vehicle – as – a – Service (VaaS).

Vehicle-as-a-Service (VaaS) constitutes a disruptive business model within the smart mobility ecosystem that leverages the underutilized computational and sensing capabilities of modern vehicles. It transforms vehicles into dynamic service platforms capable of offering various digital services, ranging from data processing to storage and communication. Modern vehicles are equipped with numerous microcomputers and sensors designed to support assisted and automated driving functions. These include cameras, LiDAR, radar systems, and other sensors that generate massive amounts of data—up to 20 terabytes per day depending on the vehicle's level of autonomy. VaaS capitalizes on these underutilized resources by offering them as services, thereby turning vehicles into data generation and processing units. The data generated by vehicles, which includes everything from event logs to customer preferences, is treated as a valuable asset. Through VaaS, this data can be used to provide services such as real-time traffic updates, safety enhancements, and even commercial data services. The concept of "infonomics" comes into play here, where vehicle data is managed and deployed in ways that generate revenue. (Khamis, 2021).

Gig Economy and Crowdsourcing.

The Gig Economy is characterized by the prevalence of short-term, flexible jobs typically undertaken by independent contractors or freelancers. These individuals engage in income – earning activities without the traditional long-term employer-employee relationship. In many cases, these freelance activities do not require previous work experience, making them accessible to a broad segment of the population. According to a study by Intuit in 2020, it was anticipated that over 80% of major U.S.-based companies would significantly increase their use of nontraditional jobs, signalling a strong growth trend for the Gig Economy (Khamis, 2021).

In the mobility context, this model has gained substantial momentum, particularly within on-demand delivery services. Several first- and last – mile transportation services rely on this model, leveraging the flexibility and scalability it offers. The COVID – 19 pandemic significantly accelerated the demand for contactless last-mile delivery services, which in turn increased the need for gig workers to carry out these tasks efficiently and cost-effectively. The pandemic highlighted the crucial role that the Gig Economy plays in the modern supply chain, particularly in adapting to sudden shifts in consumer behaviour and expectations (Khamis, 2021). Examples of companies utilizing the Gig Economy include:

- GoShare: Assists customers who need drivers or movers.
- Kanga, EZER, and Bellhops: Focus on moving services.
- Cabify, Amazon Flex, and Stuart: Specialize in delivering parcels.
- Deliv: Offers parcel delivery services.
- FedEx Express: Provides both short- and long-distance delivery services.

These companies typically utilize gig-based apps that enable crowdsourced delivery, especially for same-day and instant delivery services. The demand for these speedy delivery services has been growing rapidly, driven by consumer expectations for faster and more flexible delivery options (Khamis, 2021).

However, despite its rapid growth, the sustainability of the Gig Economy as a primary source of income for independent contractors remains a topic of debate. The low financial rewards associated with gig work, driven by short-term contracts and the availability of numerous similar service apps, raise concerns about the long-term viability of this model as a stable income source (Khamis, 2021).

Passenger Economy.

The term "passenger economy," introduced by Intel, refers to the economic and societal value that will emerge from fully autonomous vehicles (SAE level 5). This business model focuses on monetizing the user experience within driverless mobility platforms. Achieving this requires advancing to levels 3-5 of the Connected Car Customer Experience (C3X) framework, as outlined by McKinsey (Khamis, 2021).

- **Level 3** involves preference-based personalization, where passengers enjoy tailored controls and targeted contextual advertising.
- **Level 4** introduces multimodal live dialogue, enabling passengers to interact with vehicles and receive proactive service and function recommendations in real-time.
- **Level 5** offers a virtual chauffeur experience, where cognitive AI anticipates and fulfils passengers' explicit and implicit needs, handling complex, unprogrammed tasks.

As vehicles become more connected and automated, this passenger economy will allow for a variety of consumer-focused products and services, such as retail, healthcare, finance, and media, to be offered to passengers. Intel projects that this market could reach a value of $7 trillion by 2050, a figure that is double Germany’s GDP and four times Canada’s GDP in 2021. According to Strategy Analytics, the majority of this revenue (around 55%, or $3.7 trillion) will come from Mobility-as-a-Service (MaaS) as consumers move away from vehicle ownership (Khamis, 2021).

The passenger economy opens up numerous opportunities to enhance and monetize the experiences of passengers in connected, automated, and shared vehicles. Future mobility systems will likely support various subscription-based services related to education, leisure, business, and healthcare. One example is Toyota Boshoku’s Tailored Space System (MOOX), a mobile private space that can be freely utilized while in motion. Beyond personal vehicle use, autonomous vehicles could be repurposed for various business opportunities, including mobile motels, Sleep – Cabs, beauty salons, restaurants, drive-in movies, mobile stores, pharmacies, mini-clinics, and other on-the-go services (Khamis, 2021).

6. Status Quo (Good Practices & Cases).

6.1. Transport for London (TfL).

Transport for London (TfL) is the integrated transport authority responsible for managing the majority of London's public transport services, including the London Underground, buses, the Docklands Light Railway (DLR), Overground, and the Elizabeth line, among others. Operating under the leadership of the Mayor of London, Sadiq Khan, they play a critical role in shaping the city's transportation infrastructure to support the Mayor's vision of a safer, greener, and more prosperous London. This includes a commitment to sustainability, with initiatives like the Ultra Low Emission Zone (ULEZ) and the transition to zero-emission buses, all aimed at reducing car dependency and improving air quality (Transport for London, 2023).

Beyond transport operations, TfL is deeply involved in enhancing the quality of life in London by promoting active travel (walking, cycling, and public transport) with a goal of having 80% of all journeys made through these modes by 2041. TfL collaborates closely with London's boroughs to create more pedestrian – friendly streets, supports local businesses, and drives economic growth through significant infrastructure projects like the Elizabeth line and the Northern line extension. These efforts are complemented by their work in urban development, including the provision of affordable housing and the creation of jobs and apprenticeships through its supply chain (Transport for London, 2023).

As a forward – thinking organisation, they are committed to using data and technology to continuously improve its services, making them more accessible and efficient for all Londoners. During the COVID-19 pandemic, TfL implemented extensive safety measures to protect travellers and introduced initiatives like the Streetspace for London programme to encourage safe walking and cycling. As London recovers, TfL remains focused on fostering a sustainable, car – free recovery and ensuring that the city's transport network continues to support its long-term growth and resilience (Transport for London, 2023).

Transport for London (TfL) operates under a comprehensive and multi – faceted business model designed to meet the transport needs of one of the world's largest and most dynamic cities. The 2024 Business Plan outlines the key elements of TfL's approach to financial sustainability, capital investment, and service delivery, focusing on the integration of public funding, fare income, and commercial ventures to support its extensive operations and future growth (Transport for London, 2023b).

6.1.1. Funding Structure.

Regarding their funding structure, it operates under a complex funding structure designed to sustain one of the most extensive urban transport networks in the world. The financial model relies on a combination of fare revenue, government subsidies, borrowing, and commercial activities, which together enable TfL to manage day-to-day operations, invest in capital projects, and implement long-term strategic goals such as decarbonization and improving service quality. Understanding TfL's funding sources is crucial to evaluating its financial sustainability and capacity to meet the growing demands of a rapidly expanding city (Transport for London, 2023b).

Fare revenue forms the largest and most consistent source of operational funding for TfL. The income generated from the millions of passengers who use TfL's transport services daily, including the London Underground, buses, the Docklands Light Railway (DLR), and the Elizabeth line, is essential for maintaining services and infrastructure. TfL's fare structure is based on a zonal system that determines the cost of journeys based on the distance travelled, with different pricing models for peak and off-peak hours (Transport for London, 2023b).

TfL's fare collection system has evolved significantly over the years, most notably with the introduction of the Oyster card in 2003 and the subsequent adoption of contactless bank card payments. These innovations have simplified fare collection and improved operational efficiency by reducing the need for cash transactions and paper tickets. The contactless payment system, particularly, has seen widespread use, accounting for a significant portion of fare income in recent years. This technology is not only convenient for users but also allows the organisation to track passenger data more effectively, which helps optimize service delivery and pricing strategies (Transport for London, 2023b).

Despite its importance, fare revenue is subject to fluctuations based on passenger volumes, which are influenced by external factors such as economic conditions and, most notably, the COVID-19 pandemic. During the pandemic, TfL experienced a significant decline in fare income as ridership dropped by up to 95% at certain points, demonstrating the vulnerability of this revenue source. As a result, TfL's business plan for 2024 places a strong emphasis on recovering ridership levels and growing passenger demand to support financial sustainability. TfL forecasts a recovery to pre-pandemic passenger numbers by 2026/27, with four billion journeys expected annually by that time (Transport for London, 2023b).

6.1.2. Government Subsides.

Government subsidies and grants play a crucial role in TfL's ability to deliver public services, especially in funding major capital projects and supporting operations when fare revenue is insufficient. Historically, TfL received substantial operating grants from the UK government, which helped offset the costs of providing affordable public transport. However, over time, TfL has aimed to become more financially independent, with fare revenue covering a growing share of its operational expenses. Nonetheless, government funding remains essential for the successful delivery of large infrastructure projects that cannot be funded solely through fare income (Transport for London, 2023b).

For the 2024-2025 financial year, TfL will receive £250 million in capital funding from the UK government to support ongoing and new capital projects, including the replacement of Piccadilly line trains and the Docklands Light Railway (DLR) upgrades. These funds are critical for maintaining and upgrading key infrastructure, which is central to ensuring TfL's network remains reliable and efficient (Transport for London, 2023b).

While TfL's operating subsidy has decreased over the years, the government continues to provide financial support during times of crisis. The COVID-19 pandemic triggered emergency funding packages from the government, without which TfL would have struggled to maintain operations. These funding arrangements, though temporary, highlight the ongoing need for government support, particularly in unforeseen circumstances (Transport for London, 2023b).

Looking forward, their ability to secure long-term government funding agreements will be critical in supporting its ambitious capital programme and ensuring the network's resilience. That is why the current business plan emphasizes the need for a sustained funding arrangement to meet the demands of a growing city and achieve long-term transport and environmental goals (Transport for London, 2023b).

6.1.3. Borrowing and Debt Financing.

Borrowing is another important aspect of TfL's funding structure, allowing the organisation to finance large-scale infrastructure projects without relying solely on current revenues. TfL is authorized to borrow from capital markets, primarily through the issuance of bonds, and uses this debt to fund long-term investments in the transport network. Among these major projects it could be included the extension of the Northern line, the development of the Elizabeth line, and the modernization of stations and signalling systems (Transport for London, 2023b).

In the 2024 Business Plan, the organisation forecasts annual borrowing of £280 million, contributing to an overall debt portfolio of £14 billion by 2026/27. This will have a significant impact for funding projects that have a long-term payoff, such as infrastructure that will serve the city for decades to come. Spreading the cost of these projects over time through borrowing ensures that TfL can undertake necessary improvements without overly burdening its current financial resources (Transport for London, 2023b).

However, borrowing also increases TfL's long – term liabilities, meaning that debt repayment must be carefully managed. That is why they stablish strategies for balancing borrowing with revenue generation to ensure that debt remains at a sustainable level. TfL's ability to borrow also depends on maintaining a strong credit rating, which requires the organization to demonstrate sound financial management and long-term planning (Transport for London, 2023b).

6.1.4. Diversification of Commercial Activities.

In recent years, TfL has made a concerted effort to diversify its revenue streams beyond fare income and government subsidies. One of the keyways it has achieved this is through commercial activities, which include property development, retail leases, and advertising. These activities are increasingly important for the organisation's financial sustainability, as they provide a more stable and less cyclical source of income (Transport for London, 2023b):

- **Property Development:** TfL owns a significant amount of land across London, much of it located near transport hubs. This land is a valuable asset that TfL leverages to generate income through property development, particularly housing projects. TfL's property arm, Places for London, focuses on developing housing, with a commitment to building over 20,000 new homes by 2031, half of which will be affordable. Revenue from these developments is reinvested into TfL's transport infrastructure, helping fund future projects.
- **Advertising and Retail:** TfL operates the largest out – of – home advertising estate in the UK, using its network of buses, trains, and stations as advertising spaces. This generates significant revenue, particularly with the expansion of digital advertising on the Elizabeth line. Retail leases within TfL stations also provide a steady income stream, as station – based retail is an attractive proposition for businesses due to the high footfall of commuters.

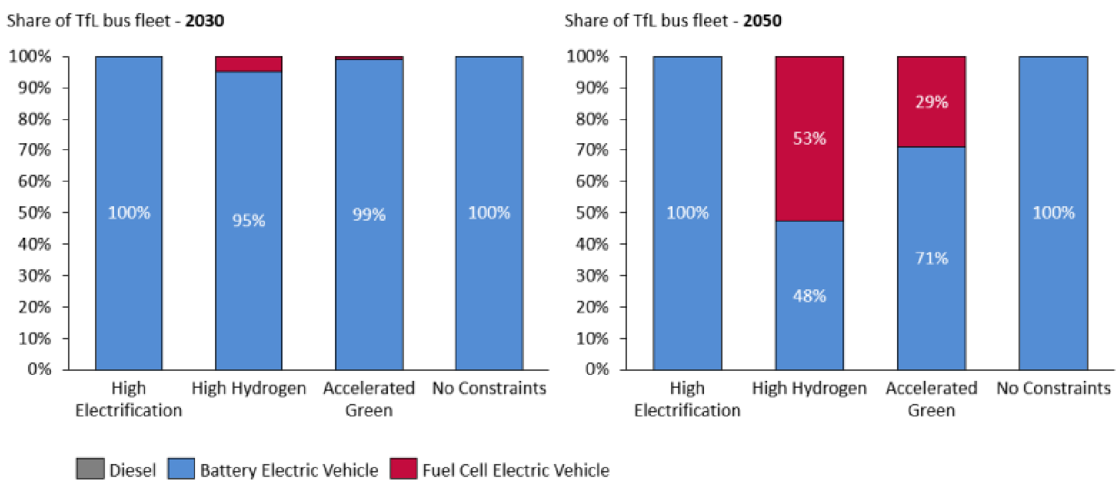
These commercial ventures not only contribute to TfL's revenue but also align with broader city goals, such as housing development and urban regeneration. By capitalizing on its property and infrastructure assets, TfL is able to diversify its income sources and reduce reliance on more volatile fare revenue (Transport for London, 2023b).

6.1.5. Environmental Impact.

Through their Annual Report (2023) they showcase the progress towards implementing the Mayor's Transport Strategy (MTS), which is a roadmap developed in 2019 by the mayor of London, Sadiq Aman, with the main objective of making London a zero – carbon emission city by 2030 and making 80% of all trips in London via active, efficient, and sustainable modes of transport by 2041 (Transport for London, 2023).

To address the climate changes the world is facing today, the organisation has been working on several initiatives such as the electrification of their bus fleet, being one of the key components in reducing carbon emissions from public transport since they contribute substantially to London's surface transport emissions. As of 2023, TfL operates over 1,180 zero – emission buses, which is one of the largest zero – emission bus fleets in Europe, and is expected to continue expanding with the goal of 9,000 fully zero-emission buses by 2034. However, with additional funding from the government, this target could be accelerated to 2030, allowing the organization to achieve its carbon reduction goals sooner, and even integrating mix of fuel cell electric buses by 2050 (**See Figure 8**) (Transport for London, 2023).

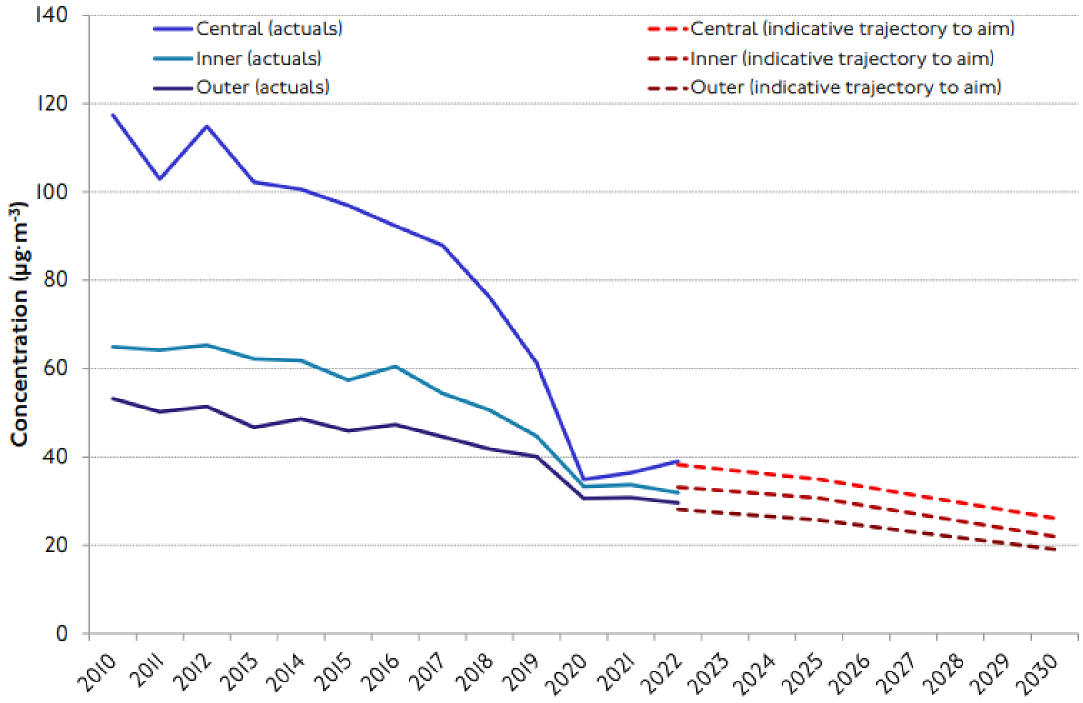
Figure 8: TfL bus fleet share by powertrain in 2030 and 2050.



Source: (Element Energy Limited, 2022)

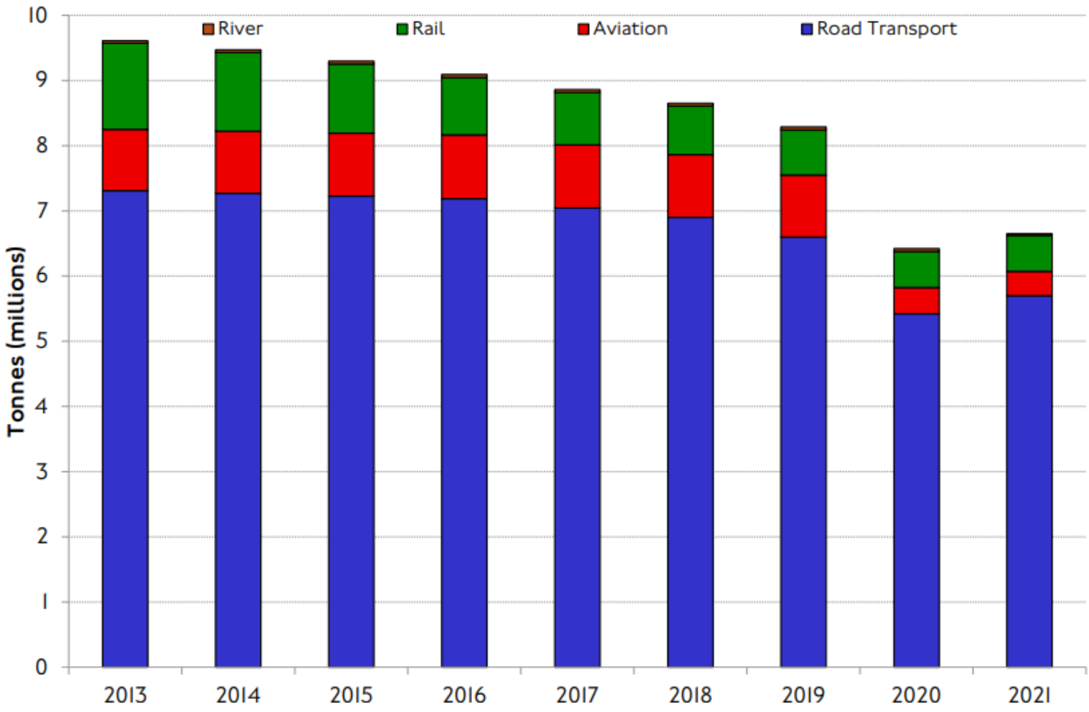
This initiative, together with the Ultra Low Emission Zone (and its expansion in 2023), allowed to reduce about 39 µg·m-3 (around 58%) of nitrogen dioxide (NO2) by 2022, against the 92 µg·m-3 in 2016, with the objective of achieving a 60 – 70% reduction by 2040 (**See Figure 9**). In addition, carbon dioxide emissions (CO_2) produced by road transport have been gradually reduced as well since 2013, from 7.3 million tonnes to 6.6 million tonnes in 2019 (around a 10% reduction) (**See Figure 10**). It is important to mention that the comparison made up to 2019 is due to the pandemic impact on the CO_2 emissions measurement, showing an even greater decrease on these emissions by 2021, but because of the confinement restrictions imposed by the government (Transport for London, 2023).

Figure 9: Average roadside nitrogen dioxide (NO_2) concentrations in London, by area, 2010 – 2030.



Source: (Transport for London, 2023)

Figure 10: Average roadside nitrogen dioxide (CO2) concentrations in London, by area, 2010 – 2030.



Source: (Transport for London, 2023)

In 2024 the Carbon Literacy Project named us as a Bronze Carbon Literate Organisation and gave the organisation a Catalyst Award for their level of ambition and achievement as part of the Carbon Literacy Action Day during COP28. We're one of only 3 organisations globally to receive this award (Transport for London, 2024).

6.2. Régie Autonome des Transports Parisiens (RATP).

6.2.1. Resources: Financial, Commercial, and Operational.

6.2.1.1. Financial Resources.

RATP's financial resources are drawn primarily from public contributions, fare revenue, government subsidies, and revenue from commercial activities. In 2023, RATP's consolidated revenue reached €6.512 billion, reflecting its capacity to sustain large-scale operations across both domestic and international markets (Régie Autonome des Transports Parisiens (RATP), 2024).

As a public entity, RATP relies heavily on financial support from government bodies, particularly Île-de-France Mobilités (IDFM), the regional transport authority. IDFM contracts RATP to provide metro, bus, tram, and RER services, compensating the company through a mix of fixed payments and incentives tied to performance metrics.

These subsidies ensure that the organisation can meet the operational costs of running a complex urban network while maintaining affordable ticket prices for passengers. A significant portion of RATP's capital investment, such as infrastructure upgrades and vehicle renewals, is funded by government subsidies as well (Régie Autonome des Transports Parisiens (RATP), 2024).

Another source of income is through fares directly charged to users/passengers. In Île – de – France, fare revenue is pooled and shared among all operators, including RATP, based on their service provision. While fare revenue is a substantial component of RATP's financial resources, its direct control over this income has been reduced in recent years due to regional fare pooling arrangements. However, fare incentives, which are linked to service quality and ridership, provide RATP with an opportunity to maximize revenue based on performance (Régie Autonome des Transports Parisiens (RATP), 2024).

RATP also uses debt financing to fund large – scale capital projects. By issuing bonds and securing loans, RATP is able to invest in long-term infrastructure projects such as the Grand Paris Express and the Bus2025 program, which aims to transition the entire bus fleet to low emission vehicles. As of 2023, RATP's consolidated net debt stood at €5.55 billion, a stable figure given the scale of its investments (Régie Autonome des Transports Parisiens (RATP), 2024).

6.2.1.2. Commercial Resources.

Regarding their commercial activity, RATP has also diversified its income streams through a variety of commercial activities that supplement its traditional public funding sources. The development and management of real estate, advertising, and telecommunications infrastructure are key areas where RATP generates additional revenue (Régie Autonome des Transports Parisiens (RATP), 2024):

- **Real Estate Development:** RATP owns extensive land and property assets, particularly in Île-de-France, which are strategically located near its transport infrastructure. These assets present a significant opportunity for revenue generation through urban development projects, including residential and commercial real estate. RATP's real estate arm, RATP Real Estate, plays a crucial role in transforming unused or underutilized spaces into valuable assets. In 2023, the company delivered nearly 300 new housing units and launched several commercial development projects, which are expected to generate future income.
- **Advertising and Retail:** RATP operates one of the largest out-of-home advertising networks in France, capitalizing on its extensive transport network.

Advertising in metro stations, on buses, and across its tram and train systems provides a steady stream of revenue. Additionally, RATP leases retail spaces within its transport hubs, offering a wide range of commercial opportunities. These activities are managed by RATP's subsidiary, RATP Travel Retail, and contribute to the organization's efforts to diversify its income streams.

- **Telecommunications and Digital Services:** RATP is also involved in telecommunications through RATP Connect, which manages the digital infrastructure supporting Wi-Fi, mobile networks, and other telecommunications services across its transport network. This infrastructure not only enhances the passenger experience but also represents a growing commercial opportunity as demand for connected services increases.

6.2.1.3. Operational Resources.

RATP's operational resources are centred on its workforce, technology, and physical assets. With over 64,000 employees globally, RATP is one of the largest employers in the urban mobility sector, and its workforce is key to delivering high – quality transport services across its networks (Régie Autonome des Transports Parisiens (RATP), 2024).

Their physical assets include a vast portfolio of 371 metro stations, 14 metro lines, two Réseau Express Régional (RER) lines, and 201 kilometres of track. These assets require constant maintenance and upgrades to ensure reliability, safety, and service continuity. In 2023, RATP continued its ambitious infrastructure improvement program, with record investments of €2.55 billion directed toward upgrading its physical assets. These investments included new rolling stock, station refurbishments, and the development of new transport lines as part of the Grand Paris Express project (Régie Autonome des Transports Parisiens (RATP), 2024) .

Thanks to their technological innovations, RATP has positioned as one of the leaders in transport innovation, particularly in the area of automated metro systems. Its expertise in automation allows the company to operate the world's largest driverless metro network, which improves service efficiency and reduces operational costs. In late 2022, RATP Dev secured a contract in AlUla, Saudi Arabia, to manage a service using three autonomous shuttles. These vehicles are remotely controlled via a specialized system developed by the company, paving the way for future job roles and operational tools in the autonomous vehicle sector. In 2023, RATP Group continued its efforts in developing and testing autonomous shuttles and buses, gaining valuable experience in adapting to increasingly complex operating environments. A significant milestone was reached when the public was able to use a 12-metre autonomous bus on route 393 as part of a trial. Another notable project was the inter – station initiative connecting Austerlitz, Lyon, and Bercy train stations, which allowed the testing of autonomous mobility in a densely populated urban area and integrated connected infrastructure through the Paris2Connect project (Régie Autonome des Transports Parisiens (RATP), 2024).

RATP is also investing in smart city solutions and Mobility as a Service (MaaS) platforms to enhance urban mobility. In November 2020, RATP Group, through its subsidiary RATP Smart Systems, acquired Mappy, the third – largest daily mobility operator in France, and the following year, RATP Smart Systems launched the MaaS app, Bonjour RATP, which enables users to access travel information, plan journeys, and purchase and validate tickets directly on their smartphones. This app integrates multiple transport options, including walking, public transport, personal bicycles, Vélib' bike-sharing, and Marcel on-demand vehicles. It also provides information on 150,000 points of interest, such as restaurants, cinemas, shops, schools, parks, and more, all of which are easily located using Mappy’s geolocation technology (Régie Autonome des Transports Parisiens (RATP), 2024).

6.2.2. Services Provided.

6.2.2.1. Urban Mobility in Île-de-France.

RATP’s core operations are focused on the Île-de-France region, where it is responsible for the operation of some of the world’s busiest and most intricate public transport systems. As previously mentioned, the company operates 14 metro lines, two RER lines (RER A and B), 371 stations, 201 kilometres of track, 120 bus routes, and multiple tram lines. These services form the backbone of Paris’s urban mobility infrastructure and are critical for the daily transportation needs of millions of residents and commuters (Régie Autonome des Transports Parisiens (RATP), 2024).

Its metro network is one of the densest in the world, providing fast and efficient transportation across Paris. It serves as the central element of the city’s public transport system, offering quick connections between neighbourhoods and key landmarks. In 2023, RATP achieved 93.5% completion of its metro service offering, ensuring a high level of reliability and availability (Régie Autonome des Transports Parisiens (RATP), 2024).

RATP manages two of the five RER lines in the Paris region, the A and B lines, which link central Paris to its suburbs and beyond. These services are crucial for commuters traveling longer distances within Île – de – France, providing regional connectivity to the metro network (Régie Autonome des Transports Parisiens (RATP), 2024).

The company’s bus fleet has been undergoing modernization, with 59% of buses now hybrid, electric, or powered by natural gas, as part of its sustainability efforts under the

Bus2025 program, which is an initiative that aims to convert the entire bus fleet and deploy infrastructure that is adapted to electric or biomethane power in each depot. The tram network has also seen significant expansion in recent years, offering efficient surface transport across key urban corridors (Régie Autonome des Transports Parisiens (RATP), 2024).

As mentioned before, RATP is at the forefront of innovation in autonomous transport solutions, operating autonomous shuttles in several parts of the region, providing a glimpse into the future of urban mobility, with a focus on reducing traffic congestion and emissions while offering reliable last-mile connectivity (Régie Autonome des Transports Parisiens (RATP), 2024).

6.2.3. Clients.

6.2.3.1. National Clients.

In its domestic market, the company's primary client is Île-de-France Mobilités (IDFM), the regional transport authority that oversees public transport policy, fare pricing, and service provision. IDFM sets the strategic direction for public transport in the Paris region and funds a significant portion of RATP's operating and capital costs. The contractual relationship between RATP and IDFM ensures that the company receives regular payments based on service performance, ridership levels, and operational efficiency. This close collaboration with the regional authority ensures that RATP remains financially sustainable while delivering high-quality public services (Régie Autonome des Transports Parisiens (RATP), 2024).

The majority of RATP's clients are the millions of daily passengers who rely on its services for commuting, education, leisure, and travel across Paris and its suburbs. To meet the needs of this broad customer base, RATP prioritizes service reliability, safety, and accessibility. The company's investments in real – time passenger information systems, mobile apps, and ticketing innovations are aimed at enhancing the overall customer experience (Régie Autonome des Transports Parisiens (RATP), 2024).

6.2.3.2. International Operations and Global Clients.

Beyond its domestic operations in France, RATP has expanded globally through its subsidiary RATP Dev, which operates public transport networks across five continents. RATP Dev manages a range of transport services, including metro systems, trams, buses, and cable cars, in cities such as London, Riyadh, Washington D.C., Casablanca, Algiers, and Sydney (Régie Autonome des Transports Parisiens (RATP), 2024).

Thanks to RATP Dev's expertise in automated metro systems, the company has been able to secure contracts to operate metro lines in cities outside France, such as Doha and Algiers, as well as tram systems in Morocco and Algeria. The company’s ability to deploy cutting-edge technology, such as fully automated lines, gives it a competitive advantage in winning international tenders. In addition to rail-based systems, RATP Dev provides bus operations in multiple global markets, including London, Washington D.C., and the Kingdom of Saudi Arabia. These services range from traditional bus routes to electric and low-emission fleets, aligned with local sustainability goals (Régie Autonome des Transports Parisiens (RATP), 2024) .

6.2.4. Expenditure.

The financial sustainability of RATP Group is integral to its ability to maintain operations, invest in infrastructure, and continue expanding its service offerings both in France and internationally. Managing expenses and addressing financial challenges is a critical aspect of the company's business model, given the complex nature of its operations and the significant capital required to run and modernize extensive transport networks.

6.2.4.1. Operating Expenses.

RATP’s day-to-day operations generate substantial expenses, especially given the scale of its network in the Île-de-France region and its global operations through RATP Dev. Operating expenses are driven by several key factors (Régie Autonome des Transports Parisiens (RATP), 2024):

- **Staff Costs:** One of RATP’s largest expense categories is wages and benefits for its more than 64,000 employees globally. The company’s workforce is integral to maintaining the safe and efficient operation of its metro, bus, RER, and tram services. As a public entity, RATP must also comply with government regulations regarding labour contracts, wages, and working conditions. In 2023, like many other companies in the transport sector, RATP faced financial pressure due to rising wage costs and absenteeism, which contributed to increased staffing expenses.
- **Energy Costs:** Another significant component of RATP’s operating expenses is energy consumption. As a large-scale operator of metro, bus, and tram services, RATP requires substantial energy resources to power its fleet and facilities. Rising energy costs, particularly during periods of economic uncertainty or geopolitical instability, can significantly impact RATP’s operational budget. In 2023, RATP experienced increased energy costs due to global energy price fluctuations, which put additional pressure on its operating margins.
- **Maintenance and Infrastructure Upkeep:** Maintaining the extensive infrastructure that supports RATP’s transport network is another major cost

centre. Regular upkeep of metro stations, tunnels, tracks, rolling stock, buses, and trams is essential to ensuring safety, reliability, and customer satisfaction. The aging infrastructure in parts of the Île-de-France region, particularly in the metro system, requires significant ongoing investment to maintain service levels and prevent service disruptions. RATP also invests in modernizing its infrastructure, such as upgrading stations, replacing outdated equipment, and deploying new technologies, all of which contribute to high maintenance costs.

- **Rolling Stock and Fleet Management:** Managing and renewing RATP's fleet of vehicles – whether metro trains, RER trains, buses, or trams—represents another substantial portion of its expenses. As part of its Bus2025 program, RATP is transitioning its entire bus fleet to electric and biogas-powered vehicles by 2025, requiring significant investment in new vehicles, charging infrastructure, and associated technologies. This shift toward a zero-emission fleet, while crucial for sustainability, comes with high upfront costs.

6.2.4.2. Infrastructure Investment.

RATP's capital expenditure is essential for modernizing its transport systems, expanding capacity, and ensuring long-term sustainability. In 2023, the company made record investments of €2.55 billion, with the majority of this capital dedicated to infrastructure improvements in the Île – de – France region (Régie Autonome des Transports Parisiens (RATP), 2024). These investments are focused on several key areas:

- **Grand Paris Express:** One of RATP's most significant infrastructure projects is its involvement in the Grand Paris Express, a major metro expansion project aimed at improving connectivity between the suburbs and central Paris. The project involves the construction of new automated metro lines and the extension of existing ones, and it is expected to significantly enhance the capacity of the Paris metro system. This project represents a long-term capital commitment, with substantial costs related to tunnelling, station construction, and the deployment of advanced technologies (Régie Autonome des Transports Parisiens (RATP), 2024).
- **Bus2025 Program:** As part of its commitment to sustainability, RATP is heavily investing in the electrification of its bus fleet through the Bus2025 program. By 2025, RATP aims to transition its entire fleet of 4,700 buses to electric or biogas power, an initiative that requires not only the procurement of new vehicles but also the installation of charging infrastructure at depots and throughout the region. The costs of implementing this program are high, but the long – term environmental and financial benefits are expected to be substantial as RATP

reduces its reliance on fossil fuels and lowers operational emissions (Régie Autonome des Transports Parisiens (RATP), 2024).

- **Infrastructure Modernization:** RATP continues to invest in upgrading its existing infrastructure, including the renovation of metro and RER stations, the replacement of rolling stock, and improvements to signalling and control systems. In 2023, RATP invested heavily in the modernization of the Line 14 metro as part of the Grand Paris Express project, as well as upgrades to other critical lines. These investments are essential to maintaining service reliability, improving passenger experience, and ensuring that the network can meet future demand (Régie Autonome des Transports Parisiens (RATP), 2024).

6.2.5. Environmental Impact.

6.2.5.1. GHG Emissions Reduction.

RATP’s commitment to reducing greenhouse gas (GHG) emissions forms a cornerstone of its environmental strategy, with significant efforts being made to align with both regional and global climate goals. The company is actively pursuing a path towards carbon neutrality by 2050, with interim goals set to achieve a 50% reduction in GHG emissions by 2025, compared to 2015 levels. These ambitious targets are supported by various projects and initiatives aimed at decarbonizing RATP's transport operations and reducing its overall carbon footprint, which are (Régie Autonome des Transport Parisiens (RATP), 2023):

- **Electrification of the Bus Fleet:** One of the central elements of RATP’s sustainability strategy is the Bus2025 program which, as mentioned before, aims to convert its entire bus fleet to electric and biogas – powered vehicles by 2025. By the end of 2023, 59% of the fleet was already running on hybrid, electric, or natural gas. This transition plays a crucial role in reducing the company’s overall carbon footprint and improving air quality in the Île – de – France region.
- **Decarbonization Targets:** RATP is committed to cutting its greenhouse gas emissions by 50% by 2025 compared to 2015 levels. This ambitious target is part of a broader strategy that aligns with UN SDGs Goals, with the objective to achieve carbon neutrality by leveraging cleaner technologies, increasing energy efficiency, and focusing on sustainable mobility solutions.

6.2.5.2. Energy Efficiency.

In its *Activity and Sustainable Development Report 2023*, the company showcases its strong commitment to efficient energy management through its energy efficiency plan. In 2023, the company reduced overall energy consumption by 12% in its industrial and office buildings, saving approximately 34.6 GWh, consequently reducing 5,250 tonnes of CO_2 emissions. In order to achieve this, RATP monitors these buildings thanks to ISO 50001 dashboards, which helps cover about 90% of energy consumed by these buildings (Régie Autonome des Transport Parisiens (RATP), 2023).

The company has also made notable strides in upgrading its infrastructure to be more energy – efficient. For instance, it replaced outdated lighting systems with LEDs, reducing energy consumption significantly. Additionally, by improving ventilation systems across metro stations and lines, RATP has enhanced air quality while lowering energy use. That being said, RATP has set a goal to reduce its overall energy consumption by 15% by 2029, compared to 2019 levels (Régie Autonome des Transport Parisiens (RATP), 2023).

6.2.5.3. Air Quality.

Improving air quality has become a central focus of RATP's environmental and public health strategy, particularly given the increasing concerns about urban air pollution and its impact on health. As one of the largest public transport operators around the globe, RATP has taken several proactive steps to reduce emissions and improve air quality both in its operations and within the environments where its services operate, such as metro stations, bus depots, and other public spaces in order to protect passengers, employees, and the broader community from harmful pollutants.

RATP has made air quality a central focus of its sustainability efforts by implementing comprehensive air quality monitoring systems throughout its metro and RER networks. These systems involve the use of advanced sensors that measure fine particulate emissions and other pollutants in stations, tunnels, and platforms. The data collected is then analysed to assess whether interventions are needed to ensure the safety and comfort of passengers and employees (Régie Autonome des Transport Parisiens (RATP), 2023).

Additionally, in 2023, RATP replaced outdated ventilation systems with newer, more efficient models. These upgrades are designed to improve airflow in metro stations and tunnels, thereby reducing the concentration of particulate matter and other pollutants. The focus on increasing ventilation efficiency is particularly important in high-traffic stations where the accumulation of dust, brake particles, and other fine particulates is most prevalent. By 2024, the company aims to replace or enhance ventilation systems in over 40 key locations across its network. This strategic approach ensures that the areas with the highest passenger volumes receive the necessary upgrades to maintain optimal air quality (Régie Autonome des Transport Parisiens (RATP), 2023).

6.3. ZipCar.

Zipcar was founded in 2000 by Robin Chase and Antje Danielson in Cambridge, Massachusetts and has since grown into the world's leading car – sharing network, with operations across the US, Canada and the UK. Zipcar provides members with access to a variety of vehicles that can be rented by the minute, hour, or day, offering a sustainable alternative to traditional car ownership (Zipcar, Inc., 2024; Comparably, 2024).

The company's mission is to enable simple and responsible urban living by offering on-demand vehicles that support environmental sustainability, reduce congestion, and free up urban space. Their vision is to create a future where car-sharing members outnumber car owners in major cities around the world. To achieve this, Zipcar emphasizes innovation in transportation, aiming for a fully electric fleet by 2030 (Zipcar, Inc., 2024; Comparably, 2024).

Zipcar's values include obsessing over the member experience, delivering simplicity through innovation, fostering personal growth, and having a positive impact by contributing to urban and environmental transformation (Zipcar, Inc., 2024; Comparably, 2024).

6.3.1. Financial and Operational Resources.

6.3.1.1. Financial Resources.

The company's primary revenue source comes from membership fees and rental charges. Membership fees range from as low as $9 per month, while rental charges are usage-based, allowing customers to pay only for the time they actually use the vehicle. This pricing model offers a competitive advantage by avoiding the high upfront costs of vehicle ownership and offering members significant savings. For instance, Zipcar estimates that its members save over $10,000 annually compared to car ownership (Zipcar, Inc., 2022).

Zipcar's focus on reducing carbon emissions is not only part of its value proposition but also attracts eco-conscious customers and partners who may be willing to invest or support the business for its environmental benefits. That is why some of its financial resources are directed toward sustainability initiatives, such as the acquisition of electric vehicles (EVs) and the development of EV charging infrastructure.

6.3.1.2. Operational Resources.

Zipcar operates a fleet of thousands of vehicles, including both traditional internal combustion vehicles (ICEs) and electric vehicles (EVs). Zipcar vehicles are distributed across multiple urban centres in cities such as New York, Boston, Washington, D.C., and others, often in high – demand areas like transit hubs, residential neighbourhoods, and business districts. The company operates about 12,000 shared vehicles, including 3,000 cars just in New York (Lagadic, Verloes, & Louvet, 2019). In addition, the company offers different types of vehicles to suit different customer needs, from compact cars for city driving to larger vehicles for group trips or transporting cargo. (Zipcar, Inc., 2022).

Regarding its technological resources, Zipcar relies on a sophisticated app and website that allow members to easily locate, reserve, and unlock vehicles. This seamless user experience is powered by GPS tracking, real-time vehicle availability updates, and a booking system that handles millions of transactions per year. Additionally, the integration of digital payment systems and partnerships with transit providers (such as integration with transit passes) helps create a seamless transportation experience for members. (Zipcar, Inc., 2022).

In order to manage the day – to – day logistics of such a wide-reaching fleet, Zipcar invests in routine vehicle maintenance, cleaning, and refuelling. This ensures that vehicles are ready for the next customer and that the service maintains a high level of reliability and user satisfaction. The operational model also focuses on reducing vehicle idle time, as privately owned cars spend 95% of their time parked. Zipcar optimizes the use of its vehicles by placing them in high-demand locations and offering a variety of reservation times (Zipcar, Inc., 2022).

6.3.2. Clients.

Zipcar primarily targets city residents who face the challenges of car ownership in urban environments—such as high parking costs, congestion, and limited space. Urban dwellers, particularly in dense metropolitan areas, are more likely to rely on public transit, biking, or walking for most of their daily transportation needs but may require a car for occasional trips. According to its *Impact Report 2022,* 85% of Zipcar’s members walk to pick up their Zipcar, which results on less CO2 emissions thanks to the less dependence on vehicles on their day – to – day trips. Zipcar provides a solution by offering access to vehicles without the hassle and cost of ownership. Moreover, 47% of their customers have a household income below the national median ($67,500 and about £51,654 in UK) (Zipcar, Inc., 2022).

Regarding its market segments, college and university campuses represent one of their main clients since many students need occasional access to a car for trips home, shopping, or leisure but cannot afford or justify owning a vehicle (about 34% are college/university students) (Zipcar, Inc., 2022). Another segment the company is also strongly positioned is on SMEs, Fortune 500 companies, and city governments, offering tailormade car sharing programmes (Zipcar, Inc., 2024b).

6.3.3. Stakeholders and Partners.

Zipcar's network of stakeholders and partners is integral to the success of its business model. These relationships help the company expand its reach, integrate into local communities, and drive both its financial and sustainability goals. The main stakeholders and partners include customers, municipalities, corporate and institutional partners, environmental organizations, and investors.

Zipcar's primary stakeholders are its members – the individuals and businesses who use its car-sharing services. Zipcar's value proposition is centred on serving the needs of these customers, and their satisfaction is crucial for the company's success. Members, through their usage patterns and feedback, shape how Zipcar operates thanks to data collection that shows their preferences for certain vehicle types, rental durations, and locations where cars are placed, allowing Zipcar to make data – driven decisions in order to better meet its customer needs. For example, in urban areas where smaller, fuel – efficient cars are more popular, Zipcar may expand its fleet of compact cars. Similarly, feedback from members about availability and convenience can drive operational improvements such as adding more cars in high – demand areas (Zipcar, Inc., 2022).

As it was mentioned before, another important stakeholder for Zipcar is municipalities and local governments, which provide crucial support in terms of policy, regulation, and physical infrastructure. Many of Zipcar's operations rely on partnerships with city governments that allocate on – street parking spaces for Zipcar vehicles, designating spots that allow the company to make its vehicles easily accessible for urban residents. In cities like New York, Zipcar has worked with the Department of Transportation (DOT) to secure on – street parking as part of a broader city – wide initiative to promote car – sharing and reduce congestion. In addition, Zipcar has established strong relationships with universities and colleges, providing affordable transportation options for students. These partnerships are valuable for students who need occasional access to a car but don't want the cost or hassle of owning one. (Zipcar, Inc., 2022).

On the other hand, Zipcar also partners with businesses to offer corporate car – sharing plans that allow employees to use Zipcar for work – related trips, reducing the need for companies to own or lease fleets, thus reducing their operational costs and their carbon footprint by encouraging the use of shared mobility options rather than relying on personal vehicles or taxis. Corporate clients benefit from the flexibility of having vehicles available for meetings, travel between office locations, or client visits without the overhead of maintaining a private fleet. In turn, Zipcar benefits from a steady stream of business users who frequently rent cars during business hours (Zipcar, Inc., 2022).

6.3.4. Environmental Impact.

Zipcar's primary environmental impact comes from its success in reducing the need for privately owned vehicles. According to their *Impact Report*, each Zipcar takes up to 13 privately owned cars off the road, leading to fewer vehicles in cities and directly contributing to reduced emissions, less traffic congestion, and freed – up parking space for other uses. Across the U.S. and Canada, Zipcar has helped take 125,839 personal cars off the road, reducing space in urban environments and the carbon emissions associated with owning and operating those vehicles. Thanks to several surveys conducted by the company and receiving feedback from its customers, Zipcar found that members drive 40% fewer miles after joining using the service, resulting on taking millions of cars off the road. In fact, members have collectively driven 2.1 billion fewer miles than they would do with a personal car, which is the equivalent of 4,500 trips to the moon and back. This has contributed on reducing their carbon footprint by 1,600 pounds annually per person (Zipcar, Inc., 2022).

Another environmental initiative is the company’s adoption of electric vehicles, and the integration of charging infrastructure help reduce the reliance on fossil fuels and contribute to cleaner urban air quality. By partnering with cities like Sacramento to provide affordable access to EVs through initiatives like the Our Community Carshare program, Zipcar has been able to deliver over 19,000 electric vehicle trips in more than 400 cities and towns across the world (Zipcar, Inc., 2022; Zipcar, Inc., 2024a)

6.4. Uber Technologies.

Uber Technologies, Inc. is a global technology platform that connects consumers with a wide range of services, using a vast network and innovative technology to facilitate movement from point A to point B. Uber operates through proprietary applications that support multiple offerings, including ridesharing, food delivery, grocery services, and logistics solutions. By linking riders with independent drivers, consumers with restaurants and merchants, and shippers with carriers, Uber provides efficient mobility and delivery services. Operating in approximately 70 countries, Uber leverages its expertise in operational excellence and product development to address everyday transportation and logistics needs (Uber Technologies, Inc., 2022).

6.4.1. Business Segments.

Uber's business model is built on a platform that leverages network effects, connecting multiple participants in a vast ecosystem. The company operates in three primary markets (Uber Technologies, Inc., 2022):

- **Mobility:** Uber's original core business, connecting consumers with ride-hailing services through independent drivers (Mobility Drivers). This segment includes ridesharing, car rentals, micromobility (e – scooters and bikes), public transit, and more. The global scale and data from millions of trips help improve service quality and pricing efficiency.
- **Delivery:** Uber Eats allows consumers to order food, groceries, alcohol, and convenience items. The Delivery segment has expanded significantly through acquisitions like Postmates and Cornershop. Uber leverages this service to increase consumer engagement with its platform, offering white-label solutions (Uber Direct) and enabling restaurants and merchants to reach a broader customer base.
- **Freight:** Uber Freight connects shippers with carriers, offering logistics services via its platform. This segment facilitates real-time shipment bookings and transparent pricing, which brings efficiency to the freight industry.

6.4.2. Value Proposition.

Uber's platform offers on – demand services that provide users with immediate access to transportation, delivery, and freight services. The convenience of booking a ride, ordering food, or arranging for goods delivery with just a few taps on a smartphone has become a hallmark of Uber's offerings. The wide variety of services (from ride – hailing to delivery) are seamlessly integrated into a single app, enhancing user experience by removing the friction of navigating multiple platforms (Uber Technologies, Inc., 2022).

For driver and couriers, the company's model empowers independent drivers and couriers by offering them flexibility in how and when they work, representing a key differentiator from traditional employment models. Drivers can choose their schedules, work part – time or full – time, and switch between Uber's services (Mobility, Delivery) to optimize their earnings. This flexibility attracts a wide pool of service providers, ensuring that the platform has a robust supply to meet customer demand, especially during peak times. By giving drivers and couriers the ability to earn income on their own terms, Uber creates a win – win proposition for both the platform and the workforce (Uber Technologies, Inc., 2022). However, it is important to mention that this operational model may vary across cities in different countries around the world, since each country has its own laws and regulations for this matter (Uber Technologies, Inc., 2022).

By operating in over 10,500 cities globally, Uber has developed a massive global network that connects millions of riders, drivers, consumers, couriers, and merchants, creating a powerful marketplace where each additional user enhances the value of the platform. The network effect improves matching efficiency, ensuring that riders get quicker rides, deliveries arrive faster, and goods are shipped more efficiently. This global reach, combined with local insights and technology, ensures that Uber can provide high reliability and scale unmatched by local competitors, while providing a continuous flow of data that allows Uber to optimise pricing, route matching, and customer preferences according to its stakeholders' needs across all the segments they operate (Uber Technologies, Inc., 2022).

6.4.3. Clients and Customer Segments.

6.4.3.1. End – Consumers.

On their *Annual Report 2022*, Uber categorises their end – consumers into two groups (Uber Technologies, Inc., 2022):

- **"Riders" (Mobility Segment):** these consumers use Uber for on – demand transportation, whether for daily commuting, occasional travel, or other purposes. Uber offers a range of ride options, from affordable shared rides to premium options like Uber Black. Riders are drawn to Uber's platform for its convenience, real – time availability, and transparent pricing, as well as the ability to choose from a variety of transportation modalities (e.g., scooters, car rentals, and public transit integrations).
- **"Eaters" (Delivery Segment):** they use Uber Eats for on – demand food delivery and grocery shopping. The platform provides access to a wide range of local restaurants, grocery stores, and other retailers. Consumers value the convenience of browsing menus, placing orders, and receiving deliveries quickly, all through the same Uber app they might use for transportation.

6.4.3.2. Drivers.

Drivers constitute independent/dependent (may vary according to geopolitical regulations) providers of ride services for ridesharing or delivery services, which are categorised by Uber accordingly (Uber Technologies, Inc., 2022):

- **Drivers (Mobility Segment):** These are individuals who provide rides to Uber's riders. Uber drivers are classified as independent contractors, giving them the freedom to set their own schedules. This flexibility attracts a broad and diverse group of earners, from full-time drivers to those looking to supplement their income on a part-time basis. The app also supports drivers with tools to maximize their earnings, such as route optimizations, surge pricing during high-demand periods, and access to financial services through partnerships.

- **Couriers (Delivery Segment):** these "drivers" focuses on deliver food, groceries, and other retail goods to end – consumers through Uber Eats and Uber Direct. Like drivers, couriers benefit from the flexibility of Uber's platform and can choose when and where to work. Uber has expanded the earning potential for couriers by allowing those without vehicles suitable for ride-hailing to participate in deliveries, further broadening its base of service providers.

6.4.3.3. Merchants.

This segment includes restaurants, grocery stores, alcohol retailers, and other local businesses that use Uber's platform to reach end – consumers and facilitate delivery services (Uber Technologies, Inc., 2022):

- **Restaurants (Delivery Segment):** Restaurants and other food merchants are key partners in Uber's Delivery segment. By using Uber Eats, these businesses can tap into Uber's large consumer base without needing to build or manage their own delivery infrastructure. Uber provides them with visibility through the app, offering marketing tools and insights to help optimize menu listings and pricing strategies. Restaurants value Uber Eats for expanding their customer reach, particularly in areas where they may not have had a physical presence.
- **Retailers (Delivery Segment):** Uber's platform extends beyond food to include grocery stores, alcohol retailers, and other local businesses. Through Uber Eats and Uber Direct, retailers can offer delivery services to customers without the overhead of managing their own delivery fleet. This allows these merchants to stay competitive in the rapidly growing on-demand economy and meet consumer expectations for fast, reliable delivery.

6.4.3.4. Shippers and Carriers.

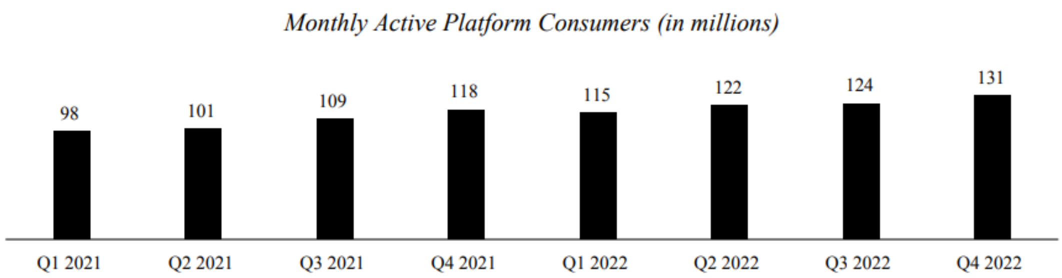
Uber Freight platform allows the connection between shippers (businesses that need goods to be moved) and carriers (trucking companies or independent truck drivers who transport these goods) (Uber Technologies, Inc., 2022):

- **Shippers:** These are businesses of all sizes, from small companies to large enterprises, that need to transport goods domestically and internationally. Shippers use Uber Freight's platform to find carriers that can move their goods efficiently. Uber offers these businesses a transparent, on – demand system with real – time pricing and tracking, making logistics easier and more reliable compared to traditional freight brokers.

- **Carriers:** Uber Freight provides carriers (truckers and logistics companies) with access to available shipping contracts, offering upfront pricing and load – booking capabilities via its platform. By using Uber Freight, carriers can quickly find loads to transport, optimizing the use of their trucks and reducing downtime between shipments.

One key metric used for customer engagement Monthly Active Platform Consumers (MAPCs), which represents the number of unique consumers (including riders and eaters) who complete at least one trip or receive at least one delivery on Uber's platform in a given month, averaged over each month of the measurement period (Uber Technologies, Inc., 2022). In 2022, Uber reported a total of 492 million of MAPCs, growing more than 15% compared to the previous year (**See Figure 11**).

Figure 11: Monthly Active Platform Consumers (MAPCs) between 2021 – 2022.



Source: (Uber Technologies, Inc., 2022)

6.4.4. Revenue Model.

6.4.4.1. Service Fees and Commissions.

Uber's primary revenue comes from service fees and commissions that it charges drivers, couriers, and merchants on each transaction facilitated through its platform. When a rider books a ride or a customer orders food, Uber collects a percentage of the total fare or delivery charge, often referred to as the take rate (Uber Technologies, Inc., 2022).

- In the **Mobility** segment, Uber collects a portion of the rider's fare, while the remaining amount goes to the driver. The commission varies by geography, service type, and market conditions, and can fluctuate due to factors like surge pricing or demand.

- In the **Delivery** segment, Uber also collects fees from both consumers and merchants, however, the rate in this segment tends to be lower than Mobility due to competitive pressures, but Uber makes up for this with higher volume and expanding services like groceries and retail delivery.

6.4.4.2. Dynamic Pricing and Surge Pricing.

Uber utilizes dynamic pricing models, which adjust fares based on real-time demand and supply conditions. During peak demand periods or in regions with limited driver availability, Uber's algorithm increases prices to balance supply with demand. This surge pricing not only helps Uber increase revenue but also ensures better service reliability by incentivizing more drivers to become available during these periods (Uber Technologies, Inc., 2022).

In high-demand situations, riders may pay significantly more, and a portion of this increased fare goes to both the driver and Uber. This mechanism allows Uber to optimize revenue, particularly during major events, holidays, or rush hours (Uber Technologies, Inc., 2022).

6.4.4.3. Subscription Services and Memberships.

Uber has introduced subscription-based services like Uber One, a cross-platform membership program that offers users exclusive benefits, including discounted rides, free delivery on Uber Eats, and priority service across its platforms (Uber Technologies, Inc., 2022).

This membership program generates recurring revenue and helps build customer loyalty. Users pay a monthly or annual fee for access to these perks, which encourages higher engagement across Uber's various offerings. This model also helps Uber smooth out revenue fluctuations tied to demand cycles, as members are incentivized to use the platform more frequently to maximize their benefits (Uber Technologies, Inc., 2022).

6.4.4.4. Advertising.

Uber launched an advertising division in 2022, offering brands the ability to market directly to users of its platform. Through initiatives like Uber Journey Ads, Uber allows advertisers to target riders and eaters with in-app ads during the ride or delivery process.

This advertising model provides Uber with a significant opportunity for revenue diversification, leveraging its vast user base and rich consumer data to offer personalized ads. Advertisers benefit from reaching consumers at multiple touchpoints (before, during, or after rides/deliveries), creating a valuable new stream of income for Uber without disrupting the core business model (Uber Technologies, Inc., 2022).

6.4.5. Competitive Landscape.

Uber operates in highly competitive markets globally across its three key business segments (Mobility, Delivery, and Freight). Each segment has established players and new entrants that challenge Uber's market share and customer loyalty (Uber Technologies, Inc., 2022).

- In **mobility**, Uber competes directly with Lyft in the U.S., as well as local ridesharing companies like Bolt in Europe, Didi in China, and Ola in India. These competitors often have a localized focus, giving them an edge in tailoring services to regional preferences and regulatory environments. Additionally, traditional transportation options, such as taxis and public transit, remain viable and often cheaper alternatives, particularly in cities where Uber's prices surge.
- In the **delivery** market, Uber Eats faces tough competition from DoorDash (U.S.), Deliveroo (Europe), Just Eat Takeaway (global), Delivery Hero (global), Glovo (Spain), Amazon (global), and so on. These competitors often offer aggressive promotions, pricing incentives, and exclusive partnerships with restaurants or grocery chains.
- In **freight**, Uber competes against established logistics players like C.H. Robinson, XPO Logistics, Convoy, and other traditional freight brokers. These competitors have long-standing relationships with carriers and shippers, giving them a significant advantage in trust and network reach.

6.4.6. Financial Overview.

6.4.6.1. Revenue Growth

In 2022, the company reported a total revenue of $31.9 billion at the end of the fiscal year, representing a notable increase of 83% from the previous year's revenue. This growth was driven largely by strong performance in its Mobility and Delivery segments, supported by an increase in the number of users and higher average gross bookings (Uber Technologies, Inc., 2022).

Breaking down the revenue obtained from each segment Uber operates, it results as follows (Uber Technologies, Inc., 2022):

- **Mobility**: This segment remains the most profitable and recorded $14 billion in revenue, an increase of 102% in comparison with the previous year revenue ($6.9 billion).
- **Delivery:** Uber Eats and related delivery services brought in $10.9 billion, a 30% increase compared to the revenue obtained in 2021 ($8.3 billion).

- **Freight:** Uber Freight, while smaller in comparison with the previous two segments, had the highest growth rate among then compared to the previous year, contributing $6.9 billion versus $2.1 billion in 2021 (a 226% increase).

6.4.6.2. Cash Flow and Liquidity

Uber's cash flow and liquidity are essential indicators of its ability to finance operations, make investments, and manage debt. Uber has been investing heavily in expanding its business, particularly through acquisitions and technology development, which has impacted its cash flow (Uber Technologies, Inc., 2022).

- **Operating Cash Flow:** Uber generated $1.7 billion in operating cash flow in 2022, up from $1.1 billion in 2021. This positive cash flow reflects Uber's ability to generate cash from its core operations, helping fund its expansion and growth initiatives.
- **Free Cash Flow:** Uber's Free Cash Flow was $390 million, which shows improvement compared to negative figures from prior years. This indicates that after capital expenditures, the company still has excess cash available to finance future growth and pay down debts.
- **Cash and Cash Equivalents:** As of December 31, 2022, Uber reported $4.2 billion in cash and cash equivalents, giving the company substantial liquidity to support ongoing operations and investments.

6.4.6.3. Profitability and Net Losses.

Despite the impressive revenue growth, Uber continues to report net losses, though the trend is improving as the company scales and focuses on cost optimization. For the year 2022, Uber reported a net loss of $9.1 billion, which was driven by unrealized losses from equity investments, increased legal and regulatory expenses, and ongoing costs related to driver and consumer incentives. As a result, Uber had an accumulated deficit of $32.8 billion by 2022, suggesting the need for the company to generate and sustain increased revenue levels and reduce proportionate expenses in the future and try to achieve profitability (Uber Technologies, Inc., 2022).

6.4.7. Environmental Impact.

Uber has committed to reducing GHG emissions across its operations, focusing on transitioning to zero-emission vehicles (ZEVs) and improving efficiency in its Mobility, Delivery, and Freight segments. To do so, they intend to focus on 4 core areas (Uber Technologies, Inc., 2024):

- **Mobility:** motivate drivers go electric via incentives that make EVs more affordable and in – app features that facilitate their charging.
- **Delivery:** assist merchants in adopting more sustainable packaging solutions by raising awareness and providing access to reusable, recyclable, and compostable materials, contributing to the global shift toward zero-emission deliveries.
- **Corporate operations:** advancing the creation of a safer, healthier, and more sustainable work environment while utilizing the benefits of renewable energy initiatives.
- **Uber Freight:** empower shippers to reduce the carbon footprint of their logistics networks by enhancing transparency, efficiency, and access to greener freight transport options; supporting motor carriers in shifting to cleaner trucks through partnerships and technology implementation.

Naturally, these actions are driven by science – based goals that will help measure the company's advances through time, while maintaining their focus and commitment on reducing the negative impacts of transportation industry on the environment. That said, Uber commits to absolutely reduce Scope 1 and 2 GHG emissions on 42%, and Scope 3 GHG emissions from use of sold products on 34% per service kilometre by 2030. On a long – term frame, the company aims to reduce Scope 1 and 2 GHG emissions on 90%, and Scope 3 GHG emissions from use of sold products on 97% per service kilometre by 2040 (Uber Technologies, Inc., 2024).

As a result, on first quarter (Q1) of 2024 Uber has accomplished that 9% of trip miles in Europe were completed in zero – emission vehicles (ZEVs), and 8.2% in the US and Canada. For this reason, Uber encourages governments to create programs and policies that promote and incentivize the use of ZEVs and EVs, alongside improving EVs' charging infrastructure and urban access for green vehicles (Uber Technologies, Inc., 2024).

6.5. Zaptec.

Zaptec is a Norwegian manufacturer founded in 2012, specializing in the development and sale of EV's charging systems. As a leading group, Zaptec has carved out a strong position in the growing market for sustainable transportation infrastructure. The company offers smart, scalable, and safe charging solutions tailored to both residential and commercial needs. Its core product lines, Zaptec Go for home use and Zaptec Pro for larger, multi – user installations, are designed to optimize energy usage through innovative technologies like phase – balancing. By offering efficient and reliable charging solutions, Zaptec is contributing to the electrification of transportation, helping reduce global CO_2 emissions and advance the global shift to electric vehicles (Zaptec ASA, 2024a).

Zaptec's mission is to "enable the growth of EVs worldwide by providing a simpler, more efficient and desirable charging infrastructure". Its vision reflects a commitment to sustainability and innovation, aiming to lead the way in developing efficient and environmentally friendly charging technologies. Through its core values—curiosity, passion, and responsibility—the group guides its strategic direction and daily operations, to provide high – quality products while adhering to ethical business practices, as evidenced by its membership in the Responsible Business Alliance. Its goals include continuous expansion across international markets, innovating in areas such as Vehicle-to-Grid (V2G) technology, and maintaining leadership in EV charging infrastructure through sustainable practices and smart energy solutions (Zaptec ASA, 2024a) .

6.5.1. Market Position and Expansion.

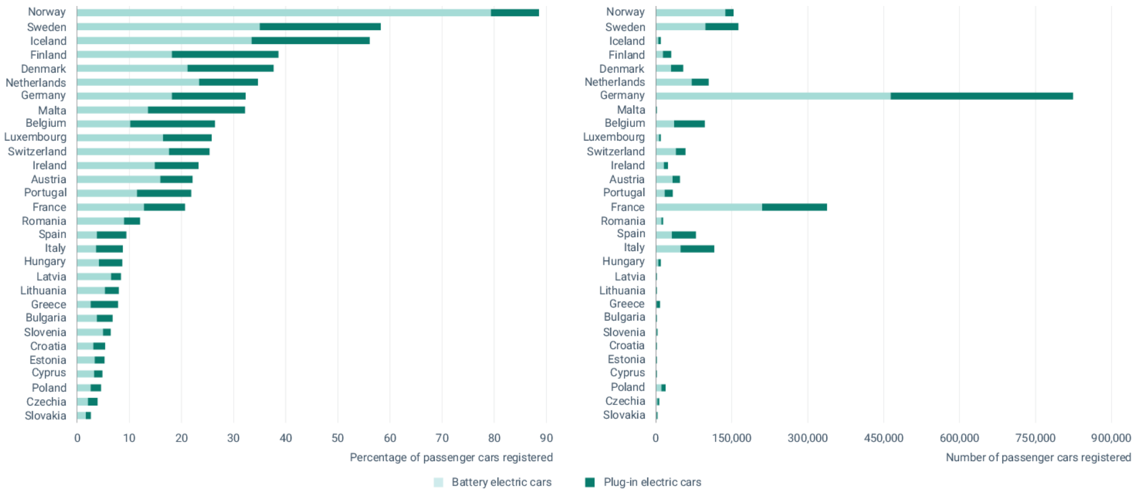
The electric vehicle (EV) market is rapidly evolving, and Zaptec has positioned itself as a key player in the charging infrastructure space. One key factor driving Zaptec's success is the rising demand for electric vehicles across Europe. Norway, particularly, leads the share of new electric car registrations among the EU – 27 and non – EU EEA countries with 89% compared with 2021 (**See Figure 12**), followed by Sweden (58%) and Iceland (56%) (European Environment Agency (EEA), 2023).

In 2019, Zaptec began its journey to international Nordics markets, particularly in Sweden, where it already holds a strong presence thanks to its brand Zaptec Sverige. However, what truly marked an inflexion point towards the group's market footprint was its strategic expansion into other European markets, particularly in the Swiss market thanks to the acquisition of NovaVolt AG in 2021 (later rebranded as Zaptec Schweiz AG in 2023). Later on, Zaptec gained market share in several EU and non – EU countries by stablishing subsidiaries in Spain, France, UK, Netherlands, Denmark, and Germany (Zaptec ASA, 2024a; Zaptec ASA, 2024b).

Zaptec has been quick to capitalize on these trends, targeting regions that show strong potential for EV adoption. The opening of its Benelux office in Amsterdam and its entry into the Spanish and Hungarian (through a distributor agreement) markets demonstrate its proactive approach in capturing new market share that allowed the group to produce more than 500,000 units by 2023. Additionally, partnerships with key players, such as Renault in France, have helped solidify its brand in these markets (Zaptec ASA, 2024a; Zaptec ASA, 2024b).

Looking forward, Zaptec is well – positioned to tap into the anticipated 20% growth in European plug – in vehicle sales in 2024, with a more significant 45% growth projected for 2025. As Zaptec continues to refine its product offerings to fit regulatory standards in various markets, the company is gearing up to play a pivotal role in the mass – market adoption of EVs (Zaptec ASA, 2024a).

Figure 12: Newly registered electric cars by country.



Source: (European Environment Agency (EEA), 2023)

6.5.2. Key Products.

As previously mentioned, the company's two flagship products, Zaptec Pro and Zaptec Go, are key drivers of its growth, offering versatile and innovative solutions to cater to the increasing demand for electric vehicle (EV) charging infrastructure (Zaptec ASA, 2024a).

6.5.2.1. Zaptec Pro.

This product is specifically designed for multi – user environments, such as apartment complexes, commercial buildings, and large – scale installations. Its intelligent load – balancing feature is what sets it apart from many competitors. In multi-user settings, electric energy can often be a scarce resource, leading to increased costs and longer charging times. Zaptec Pro, through its smart algorithms, allows multiple EVs to charge simultaneously by sharing the available energy efficiently, rather than charging vehicles one at a time (Zaptec ASA, 2024a).

With features like load balancing and remote updates, Zaptec Pro ensures that the system can handle growing EV usage without the need for expensive upgrades to the electrical grid. A major milestone for the product came in 2023, when the MID energy meter approval was secured, making it compliant with stringent European regulations on energy measurement accuracy. This approval opens the doors for Zaptec Pro to be sold in major European markets where compliance is essential, such as Germany, France, and the Benelux countries (Zaptec ASA, 2024a).

One of the standout installations of Zaptec Pro was at Oslo's Gardermoen Airport, where over 240 units were installed in 2023, with plans for further expansion. This project underscores the product's ability to cater to large-scale installations, meeting both immediate and future demand for charging points (Zaptec ASA, 2024a).

6.5.2.2. Zaptec Go.

Unlike Zaptec Pro, which is built for larger infrastructure, Zaptec Go is tailored for individual households. It is a compact, user-friendly solution designed for residential use, allowing homeowners to easily charge their EVs without the need for complex installations. The product is versatile enough to be installed in homes, garages, or smaller apartment complexes (Zaptec ASA, 2024a).

Zaptec Go stands out for its sleek design and compatibility with various EV models. It supports fast charging up to 22 kW, ensuring that EVs can be charged quickly and efficiently. Moreover, Zaptec Go offers smart charging capabilities, allowing users to schedule charging sessions during off – peak hours when electricity rates are lower, thus reducing energy costs (Zaptec ASA, 2024a).

Zaptec Go has seen success in multiple European countries, including the UK, where it was specifically adapted to meet the country's unique regulatory standards with a 7kW version launched in early 2023. By aligning its product with local market requirements, Zaptec ensures it can effectively compete in various national markets (Zaptec ASA, 2024a).

6.5.3. Key Stakeholders and Partnerships.

Zaptec's success is not only driven by its innovative products but also by the strength of its partnerships and relationships with key stakeholders. In the rapidly growing electric vehicle (EV) charging market, building strategic alliances with manufacturers, distributors, and industry bodies is essential for scaling and delivering high-quality solutions. Zaptec has done this masterfully, leveraging partnerships to expand its market presence, improve its technology, and solidify its position in key regions.

6.5.3.1. Production Partners.

A significant part of Zaptec's operational success lies in its collaboration with two main production partners: Westcontrol in Norway and Sanmina Corporation in Germany. These partnerships have allowed Zaptec to scale its production to meet growing demand, especially as its presence in European markets has expanded. The collaboration with Westcontrol has been key in ramping up the production of Zaptec Go, while Sanmina's factory in Germany started production in 2023 to further boost supply. This expanded production capacity has been crucial in keeping up with the record-breaking order intake in early 2023 (Zaptec ASA, 2024a).

6.5.3.2. Automotive Partnerships.

In 2023, Zaptec made a significant breakthrough by partnering with Renault, one of the largest automobile manufacturers in Europe. Through this collaboration, Zaptec became Renault’s official supplier for home charging solutions, with all Renault dealerships recommending Zaptec Go as the preferred choice for EV owners, opening doors to a broader customer base across Europe, where Renault has a strong market presence (Zaptec ASA, 2024a).

6.5.3.3. Strategic Distributors.

Zaptec’s distribution network has been a key enabler of its international expansion. In 2023, the company signed agreements with its first distributors in Spain and Hungary, two markets where EV adoption is gaining momentum. These partnerships are vital as Zaptec aims to establish itself in emerging markets where infrastructure development is still in its early stages. Spain, for example, has set ambitious goals for EV adoption, targeting 5.5 million electric cars by 2030, and Zaptec is strategically positioned to supply the charging infrastructure necessary to meet this demand (Zaptec ASA, 2024a).

Similarly, in Hungary, Zaptec is leveraging its early entry to capture market share as the country reaches the critical 5% EV share in new car sales, a key turning point in EV adoption (Zaptec ASA, 2024a).

6.5.3.4. Partnerships with Large – Scale Installations.

As mentioned in the previous section, one notable example of large – scale project is Zaptec’s ongoing partnership with Oslo Gardermoen Airport, where the installation of 750 EV chargers is planned, from which 244 have already been placed by the end of 2023. This partnership not only highlights Zaptec’s capability to deliver on massive infrastructure projects but also reinforces its leadership in providing solutions for high-demand areas like airports (Zaptec ASA, 2024a).

6.5.3.5. Responsible Business Alliance (RBA).

In 2023, Zaptec became a member of the Responsible Business Alliance (RBA), the world’s largest industry coalition dedicated to responsible business practices across global supply chains. This membership signals Zaptec's commitment to sustainability, corporate responsibility, and ethical supply chain management, while aligning itself with some of the most respected companies in the electronics and automotive industries, enhancing its credibility and strengthening its reputation as a socially responsible organization (Zaptec ASA, 2024a).

6.5.3.6. Financial Partnerships.

In November 2023, Zaptec secured a new financial partnership with DNB, a leading Norwegian bank, which increased the company's credit facility from NOK70 million to NOK300 million. This expansion of financial resources, backed by Export Finance Norway, provides Zaptec with greater liquidity and flexibility to fuel its growth strategy. Such financial partnerships are critical for Zaptec as it continues to scale its operations, particularly in light of growing demand and the need to invest in new markets and innovations (Zaptec ASA, 2024a).

6.5.3.7. Post – Divestment Partnerships.

Another notable strategic decision was Zaptec's divestment of Charge365, a non-core asset, to Wattif EV in late 2023. While the divestment allowed Zaptec to sharpen its focus on its core business of charging infrastructure, the two companies entered into a frame agreement that ensures continued collaboration. Zaptec charging stations will now be deployed across Wattif's markets, particularly targeting housing cooperatives and multi-family homes. This type of post-divestment partnership allows Zaptec to maintain a presence in sectors it has exited while still capitalizing on the growing demand for its products (Zaptec ASA, 2024a).

6.5.4. Key Stakeholders and Partnerships.

Innovation is at the heart of Zaptec's mission, and the company's focus on pushing the boundaries of electric vehicle (EV) charging technology has been a key driver of its growth. In 2023, Zaptec undertook a range of ambitious projects and introduced cutting-edge technologies that not only enhanced its product offerings but also solidified its position as a leader in the EV charging infrastructure space. These innovations are not only designed to improve the functionality of their products but also to address larger industry challenges like grid overload, energy management, and sustainability.

6.5.4.1. Patented Phase – Balancing Technology

One of the most significant breakthroughs for Zaptec in 2023 was securing a pan – European patent for phase – balancing technology. This technology is a game – changer in the EV charging industry, especially in environments where multiple vehicles need to be charged simultaneously, such as apartment complexes, commercial buildings, and public infrastructure (Zaptec ASA, 2024a).

The phase – balancing technology allows the system to distribute electrical load more efficiently across different phases, preventing overload on the grid. This enables faster charging times, more efficient energy use, and significant cost savings for large installations. As a result, Zaptec is addressing one of the core challenges of EV adoption: ensuring that existing electrical infrastructure can handle the increased demand without expensive and disruptive grid upgrades (Zaptec ASA, 2024a).

It is important to highlight that this innovation is not only patented across Europe but also approved in key global markets such as China and Japan. It provides a clear competitive edge, as it makes Zaptec's charging solutions more efficient, scalable, and adaptable to various international markets. By securing this patent, Zaptec ensures that its technology remains unique and protected, preventing competitors from replicating its solutions in these regions (Zaptec ASA, 2024a).

6.5.4.2. Vehicle – to – Grid (V2G) Technology

Another forward – thinking project that Zaptec has been exploring is Vehicle – to – Grid (V2G) technology, which could revolutionize the relationship between electric vehicles and the energy grid. V2G technology allows EVs to not only draw energy from the grid but also return surplus energy back to it. As electric vehicles continue to grow in popularity, they collectively represent a vast, mobile energy storage network that could be tapped into during periods of high demand or low energy production (Zaptec ASA, 2024a).

Zaptec is actively working on solutions that will enable bi – directional charging, allowing EVs to act as power sources in their own right. This technology could open the door to new business models where users can sell excess energy stored in their EVs back to the grid, particularly during times when green energy production is low. By integrating V2G technology into its products, Zaptec is positioning itself at the forefront of the energy transition, creating solutions that benefit both individual consumers and the broader energy ecosystem (Zaptec ASA, 2024a).

6.5.4.3. Zaptec Academy: Industry's First Digital Learning Platform

Another unique innovation launched by Zaptec in 2023 is Zaptec Academy, the industry's first dedicated digital learning platform for electricians. The platform is designed to offer comprehensive training on how to safely and efficiently install Zaptec's EV charging solutions, with a particular focus on compliance with local standards and regulations (Zaptec ASA, 2024a).

The impact of Zaptec Academy has been immediate, with over 300 certified Zaptec electricians in Norway alone within just a few weeks of launch. This initiative addresses a critical bottleneck in the EV charging infrastructure market: the need for skilled installers. By providing this training, Zaptec ensures that its products are installed correctly and efficiently, which is crucial for scaling EV infrastructure. Additionally, the academy allows Zaptec to set industry standards for installation quality, further solidifying its leadership role in the EV charging space (Zaptec ASA, 2024a).

6.5.4.4. Sustainability – Focused Projects

In line with its commitment to sustainability, Zaptec has launched several initiatives aimed at reducing the environmental impact of its products. One such project is the company's focus on refurbishing and recycling older charging stations. Between 2020 and 2023, Zaptec successfully refurbished 2,466 charging stations and responsibly recycled 1,586 units, showcasing its clear commitment with the group's goals (Zaptec ASA, 2024a). These efforts not only contribute to waste reduction but also extend the lifespan of Zaptec's products, minimizing the need for new materials and contributing to circular economy. By focusing on sustainability at both the production and end – of – life stages, Zaptec is aligning its business practices with broader environmental goals, making their solutions attractive for eco – conscious consumers and organizations.

6.5.4.5. Zaptec Pro with MID Energy Meter

As mentioned before, Zaptec launched an updated version of its Zaptec Pro charging system in 2023, now equipped with a MID energy meter that monitors how much power is used in each charging session from the display on the charging station. This feature ensures compliance with the Measuring Instruments Directive (MID), a European standard that governs the accuracy of energy measurement in many markets (Zaptec ASA, 2024a).

6.5.5. Financial Overview.

6.5.5.1. Revenue Growth

Zaptec's revenue surged by a remarkable 94% in 2023, climbing from NOK737 million in 2022 to NOK1.4 billion. This substantial increase was driven by a combination of factors, including higher market activity, expansion into new European markets, and increased demand for both the Zaptec Go and Zaptec Pro product lines. The rise in export share from 69% in 2022 to 72% in 2023 reflects Zaptec's growing international presence, with key markets like Switzerland and Sweden leading the way (Zaptec ASA, 2024a).

6.5.5.2. Gross Margin Stability

Despite the rapid growth in revenue, Zaptec maintained a healthy gross margin of 38% in 2023, only slightly down from 39% in 2022. This minor decline was largely attributed to a shift in the product mix, with Zaptec Go accounting for a larger portion of sales relative to the Zaptec Pro, as well as increased transport costs and price adjustments in certain markets (Zaptec ASA, 2024a).

Maintaining a solid gross margin amid aggressive market expansion highlights Zaptec's ability to manage costs effectively, even as it scales. This is especially notable given the increased competition in the EV charging space and the logistical challenges of expanding production across multiple regions.

6.5.5.3. Operating Expenses and Profitability

Total operating expenses rose from NOK311 million in 2022 to NOK492 million in 2023, primarily driven by a significant increase in personnel and marketing expenses. Employee benefit expenses alone jumped from NOK157 million to NOK248 million, reflecting the company's investment in talent to support its rapid growth. By the end of 2023, Zaptec employed 190 people, up from 150 in the previous year, highlighting its commitment to scaling its workforce in line with its expanding operations (Zaptec ASA, 2024a).

While these increased expenses were expected as part of the company's growth strategy, they did not prevent Zaptec from turning a profit. The company recorded an EBITDA of NOK43 million in 2023, a significant improvement from an EBITDA loss of NOK25 million in 2022 (Zaptec ASA, 2024a).

6.5.5.4. Operating Profit and Net Income

Zaptec's operational turnaround was even more evident in its operating profit, which reached 13.2 million NOK in 2023, a sharp reversal from an operating loss of NOK45.5 million in 2022. This improvement was driven by higher sales volume, operational efficiencies, and a focus on core business activities following the divestment of non – core assets like Charge365 (Zaptec ASA, 2024a).

Net income followed a similar upward trajectory, with the company posting a net profit of NOK22.2 million in 2023, compared to a net loss of NOK52.9 million in the prior year. This recovery in profitability underscores Zaptec's successful execution of its growth strategy while managing operational costs and risks (Zaptec ASA, 2024a).

6.5.5.5. Liquidity and Financial Flexibility

Zaptec ended 2023 with a strong liquidity position, boasting a total available liquidity of NOK441 million, including an unused overdraft facility of NOK300 million thanks to the agreement with DNB and backed by Export Finance Norway, guaranteeing 50% of the credit limit (Zaptec ASA, 2024a).

6.5.5.6. Order Backlog and Future Outlook

Zaptec's strong financial performance in 2023 was also supported by a healthy pipeline of future orders. The company reported total purchase orders of NOK1.7 billion in 2023, with an order backlog of NOK451 million set for scheduled deliveries throughout 2024 (Zaptec ASA, 2024a).

Looking ahead, Zaptec expects sustained growth as the market for EVs continues to expand, particularly in Europe, where new CO2 regulations and the introduction of more affordable electric vehicles are expected to drive demand for charging infrastructure. The company's focus on delivering high-quality, innovative solutions, combined with its strong financial position, leaves it well-placed to capture a larger share of this growing market (Zaptec ASA, 2024a).

6.5.6. Environmental Impact.

Zaptec's commitment to sustainability and minimizing its environmental impact is evident throughout its 2023 Sustainability Report. The company has integrated responsible practices into its business model, focusing on reducing its carbon footprint, managing resources effectively, and promoting circularity within its operations. Below is a detailed analysis of the company's environmental impact and its commitment to a sustainable future:

6.5.6.1. Climate Stewardship

Zaptec actively contributes to the global effort to combat climate change. The company aligns its strategies with the objectives of the Paris Agreement and seeks to reduce its overall carbon emissions. Zaptec recognizes the dual role it plays: not only does its business contribute to climate change (through production and supply chains), but it also offers solutions that help address it. Zaptec's products, particularly its electric vehicle (EV) chargers, are designed to support the electrification of transportation and optimize the use of available power, thereby reducing dependency on fossil fuels and limiting grid overloads (Zaptec ASA, 2023).

One of the company's key initiatives is its Greenhouse Gas (GHG) emissions accounting, where Zaptec tracks and reports on all three scopes of emissions (Scope 1, 2, and 3). Zaptec's total emissions for 2023 amounted to 41,425 tCO2e, a significant increase from 2022 due to rapid production growth and the expanded use of its products. Despite this rise, Zaptec has implemented numerous measures to mitigate its environmental impact, including optimizing logistics and promoting the use of renewable energy in the use of its chargers. The company aims to increase the share of renewable energy used in its operations from 60% in 2023 to 100% by 2027, particularly in countries like Norway, where renewable energy sources dominate. This transition to renewable energy is part of its broader strategy to limit emissions from office locations and production facilities (Zaptec ASA, 2023).

6.5.6.2. Circularity and Resource Efficiency

Between 2020 and 2023, Zaptec successfully refurbished 2,466 EV charging stations and responsibly recycled 1,586 units, diverting them from landfills and recovering valuable materials in the process. These efforts not only reduce the environmental impact of producing new units but also help address the growing issue of electronic waste, which is a significant concern for the electronics industry (Zaptec ASA, 2023).

In 2023, Zaptec joined the Responsible Minerals Initiative (RMI), taking a proactive stance to ensure that the minerals used in its products are sourced responsibly. This includes monitoring the supply chain for conflict minerals and taking steps to ensure transparency at every level, from smelting to manufacturing. The company has also implemented initiatives to increase the use of recycled and recyclable materials in its packaging and product design, aiming to minimize waste and protect natural habitats (Zaptec ASA, 2023).

6.5.6.3. Optimizing Energy Use and Grid Management

Zaptec's products are designed with a strong focus on energy optimization. One of the most significant environmental benefits of its technology is the ability to optimize energy distribution and reduce the need for grid expansion. By using load – balancing algorithms, Zaptec chargers allow multiple EVs to charge simultaneously, efficiently using the available energy. This reduces the strain on power grids, lowers installation costs, and contributes to more sustainable energy consumption (Zaptec ASA, 2023).

Another way Zaptec displays its commitment to energy management is through the implementation of V2G technology on their EV chargers. This innovation aligns with the global shift toward smart grids and renewable energy, allowing energy produced during surplus periods (e.g., sunny days for solar power or windy weekends for wind turbines) to be stored in EVs and used during periods of lower production (Zaptec ASA, 2023).

6.5.6.4. Reducing Emissions in the Supply Chain

Zaptec is aware that the vast majority of its emissions arise from its Scope 3 activities, which include the production of goods and services, upstream transportation, and the use of sold products. In 2023, 99.8% of its total emissions were attributed to Scope 3 activities, with purchased goods and services contributing the largest share (28,253 tCO2e). To mitigate these emissions, Zaptec has optimized logistics by consolidating deliveries into fewer, larger shipments and reducing emissions from business travel through smarter travel practices (Zaptec ASA, 2023).

Furthermore, Zaptec is committed on encouraging its customers to use renewable energy when charging their EVs. The group collaborates with academic institutions, such as the University of Stavanger, to engage younger generations in the development of technologies and strategies that encourage renewable energy use in EV charging (Zaptec ASA, 2023).

6.5.6.5. Commitment to Transparency and Accountability

Transparency is a core pillar of Zaptec's sustainability strategy. The group values open communication and reporting on its environmental performance, ensuring accountability through partnerships with organizations like the UN Global Compact and the RBA. Moreover, in 2023, Zaptec signed the anti – greenwashing principles, reinforcing its commitment to truthful and reliable sustainability claims (Zaptec ASA, 2023).

The group's sustainability department, established in 2023, plays a crucial role in monitoring Zaptec's environmental impact, conducting human rights due diligence, and ensuring compliance with environmental policies across its operations and supply chain (Zaptec ASA, 2023).

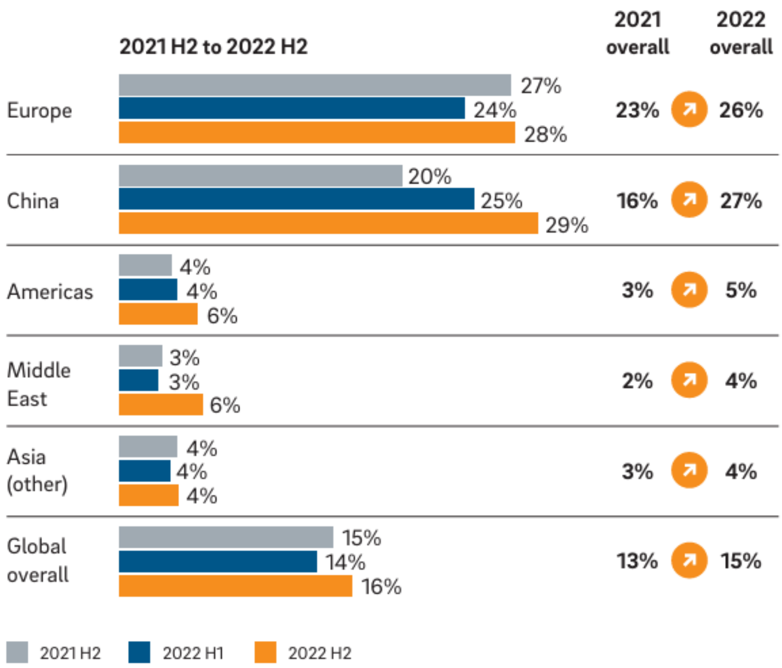
7. Future Trends.

To envision the future landscape of smart mobility most disruptive innovations, three different technological trends are analysed in this section. To do so, a supportive tool was needed in order to determine which factors are driving change in automotive ecosystems, how these evolve over time, and what can decision makers do to best manage disruption. For this case, the Automotive Disruption Radar from Roland Berger is used. From the 26 indicators contained in the Radar, only two have a score of 5 (in a scale from 0 to 5), namely R&D intensity – Autonomous driving and EV Portfolio (**See Anex V**). Since last indicator is too generic, encompassing a wide range of solutions. Therefore, EV/PHEV charging infrastructure indicator is considered to be a better fit for this purpose, while still having an important research scope as mentioned in previous chapters.

7.1. EV/PHEV Charging Infrastructure.

Since of 2023, the electric vehicle (EV) market had been experiencing significant growth, particularly in Europe, China, and the U.S., due to a combination of government regulations, technological advancements, and consumer demand for sustainable transportation. EV sales penetration has reached record highs, with some markets like China and Europe at the forefront (**See Figure 13**) (Roland Berger GmbH, 2023). This global EV adoption is driven mainly by the increasing regulatory pressure imposed by governments to reduce emissions and phase out internal combustion engine (ICE) vehicles by 2035 in many regions, Europe among them (Maisonnier, Longstaff, Vilchez, Gaudemer, & Abdallah, 2022).

Figure 13: EV Sales Penetration Rates (2021 – 2022).



Source: (Roland Berger GmbH, 2023)

This rapid increase in the number of EVs has placed immense pressure on developing public charging infrastructure. In regions like Europe and China, public charging stations are growing in number to support their fast growth on EV fleets. For example, the European EV fleet is expected to grow by 34% annually, from 4.4 million units in 2022 to 45.5 million in 2030, leading to a corresponding need for robust charging infrastructure (Maisonnier, Longstaff, Vilchez, Gaudemer, & Abdallah, 2022). For this reason, Europe has become a global leader in EV infrastructure development, with substantial investments being made in public charging networks to accommodate the EU's commitment to phasing out ICE vehicles. Countries like Norway, Germany, and the Netherlands have positioned as leaders in EU according to Roland Berger's EV charging index, closing the gap score between them and China (global leader). This showcases EU's improvements on charging networks and infrastructures, however, there is still a need to improve access across other regions, such as Hungary, Portugal, and Belgium (Roland Berger GmbH, 2023).

China, as major player in the market, leads the deployment of fast – charging (DC) stations and boasts a higher proportion of fast chargers compared to other regions. By the second half of 2022, China had more than 42% of its public chargers classified as fast chargers, which is crucial for reducing "range anxiety" among EV drivers (Roland Berger GmbH, 2023).

On the other hand, despite EV sales across the U.S. have grown fast, about 55% in 2022, the sales' penetration rate of EVs was way lower in comparison with EU's and China's, approximately 6.8%. Despite this, the government of the U.S. has already taken measures to narrow this gap by new laws and investments programs such as the Inflation Reduction Act (IRA) and National Electric Vehicle Infrastructure (NEVI), that allocated billions of dollars to build charging stations, with the goal of developing a comprehensive network by 2030 (Roland Berger GmbH, 2023).

The undergoing growth of EV charging market brought significant technological advancements, aiming to improve the efficiency, accessibility, and sustainability of charging solutions. These innovations are critical for supporting the mass adoption of electric vehicles (EVs) and addressing key challenges such as charging speed, range anxiety, and grid integration. Among the technological innovations shaping the EV charging landscape, it is important to mention:

- **DC Fast Charging:** one of the most impactful advancements in EV charging technology is the development of Direct Current (DC) fast chargers. These chargers can deliver high power, typically between 50 kW and 350 kW, enabling EVs to charge in a fraction of the time compared to traditional Alternating Current (AC) chargers. Fast charging is particularly important for public charging networks, especially along highways, where drivers need to recharge quickly during long trips (Roland Berger GmbH, 2023).
- **Ultra – Fast Charging (HPC):** by delivering over 150 kW, this technology is expected to play a key role in the future of EV charging. HPC stations can recharge an EV to 80% in less than 20 minutes, addressing range anxiety and making EVs more convenient for long-distance travel. These chargers are becoming more prevalent in key markets like Europe and China, where the demand for fast, convenient public charging is rising (Maisonnier, Longstaff, Vilchez, Gaudemer, & Abdallah, 2022).
- **Vehicle – to – Grid (V2G) Integration:** as already seen in previous chapters of this study, V2G technology has clearly been an investment focus for many companies and governments around the world thanks to the positive implications this novel technology brings on energy efficiency and circular economy. The U.S. leads the way in V2G pilots, conducting several projects in 2023, however, it is still not scaled commercialised in the market (Roland Berger GmbH, 2024).

Public charging networks are projected to grow in importance, with market estimates suggesting that public charging could account for up to 50% of the market by 2030 (Roland Berger GmbH, 2024). As more urban residents transition to EVs, the need for accessible charging solutions, particularly in areas where private home charging is not feasible, will drive the development of dense public charging hubs. These hubs will likely integrate multiple charging technologies, including fast and V2G charging, to cater to different user needs and energy demand.

By 2040, EVs are expected to dominate new vehicle sales in major markets like Europe, North America, and China, driving a parallel expansion of public and private charging networks. Today's startups, Zaptec ASA as an example, play a crucial role on supporting EVs chargers' market growth and development, especially in private areas where they still lacking. The increasing demand for charging infrastructure could be met with accelerated deployment of high – power charging stations, particularly in urban centres and along highways. This shift towards rapid and ultra – fast charging will be essential to address the needs of long-distance drivers and alleviate range anxiety.

7.2. Autonomous Vehicles (AVs).

Currently, the autonomous vehicle industry locates at Level 3 (L3) on the Society of Automotive Engineers (SAE) scale, meaning that today's vehicles can operate independently in specific conditions, but human intervention is still required in order to avoid certain risk conditions such as bad weather conditions, an error occurred in the automated driving system, or if the operating system has reached its operational limits. L4 and L5 vehicles, which are fully autonomous, are still in the testing and development phases (Khamis, 2021; McKinsey & Company, 2024).

Several companies have already launched commercial pilot programs for autonomous taxi services, with companies like Waymo and Cruise operating in controlled environments. However, widespread adoption has been delayed due to technical challenges, such as the complexity of decision – making algorithms and navigating unpredictable environments (McKinsey & Company, 2024).

Achieving full autonomy (L4 and L5 levels) requires substantial investments in software and validation technologies (sensors, radar systems, LiDAR, and so on). That is why investors, since 2010, have poured $320 billion in mobility technologies, with $106 billion going only to autonomous technology (Holland-Letz et al., 2021).

Autonomous trucking is poised to be one of the first large – scale commercial applications of AV technology, with Aurora Driver positioned as one of the leading companies providing both hardware and software self – driving systems. This is due to the controlled nature of highways and the economic advantages of driverless freight, such as reduced labour costs and increased operational efficiency. Shifting to this solution will likely reshape global supply chains, allowing logistics companies to optimize long – haul transportation routes, improve delivery speeds, and cut down on emissions through more efficient driving patterns.

While there is significant enthusiasm about the future of AVs, public trust remains a hurdle. Globally, 58% of surveyed individuals believe that L4 and L5 AVs should be on the roads by 2030, but only 47% say they would be comfortable riding in one by then. This shows a gap between technological optimism and personal readiness, with concerns primarily focused on safety. Infrastructure concerns and regulatory uncertainty contribute to this hesitation, with only 27% of people believing their countries are adequately preparing for AV deployment (Roland Berger GmbH, 2021).

8. Conclusion and Recommendations.

Summarising, the study reveals how emerging trends and case studies in the field of smart and sustainable mobility are shaping the future of transportation. Through the exploration of real – world examples like Transport for London (TfL), Régie Autonome des Transports Parisiens (RATP), ZipCar, and Uber, we gain valuable insights into the operational models, challenges, and opportunities these organizations face in transitioning to a smarter, more sustainable urban mobility landscape.

The case studies examined highlight that public and private sectors are actively integrating sustainability into their business models and operational strategies. Transport for London (TfL) stands as a prominent example, having implemented the Ultra Low Emission Zone (ULEZ) and set ambitious goals for reducing car dependency through expanded public transport networks and pedestrian-friendly streets. TfL's success showcases how well-planned government-led initiatives can reduce urban pollution and encourage green mobility. Similarly, RATP's efforts in Paris demonstrate the effectiveness of diversification and public-private collaborations in modernizing transport systems while keeping environmental impact at the forefront.

From the private sector, ZipCar and Uber provide compelling illustrations of how mobility services can reduce car ownership, traffic congestion, and emissions. ZipCar's car – sharing model taps into the growing consumer demand for access over ownership, enabling users to rent vehicles on-demand, reducing the total number of cars on the road. Meanwhile, Uber's global reach and flexible ride-hailing options showcase the potential for digital platforms to connect diverse modes of transport, making urban mobility more efficient and scalable.

As a result, policymakers should focus on expanding electric vehicle (EV) infrastructure, developing flexible regulatory frameworks for improving saft concerns on autonomous vehicles (Avs), and foster strong public – private partnerships to accelerate the adoption of sustainable mobility. Strategic investments in charging networks, renewable energy, and scalable urban designs will be crucial for accommodating future technological advancements. By facilitating collaboration between public entities like Transport for London (TfL) and private firms, governments can ensure that infrastructure development keeps pace with innovation while maintaining environmental and safety standards.

In addition, building public trust through awareness campaigns and ensuring inclusive mobility solutions for underserved communities will help drive adoption. Policymakers should also leverage available financial incentives and sustainability grants to encourage green mobility investments. Maintaining high safety protocols and environmental considerations will ensure that future smart mobility systems align with long-term sustainability goals, creating more resilient and efficient urban transportation ecosystems.

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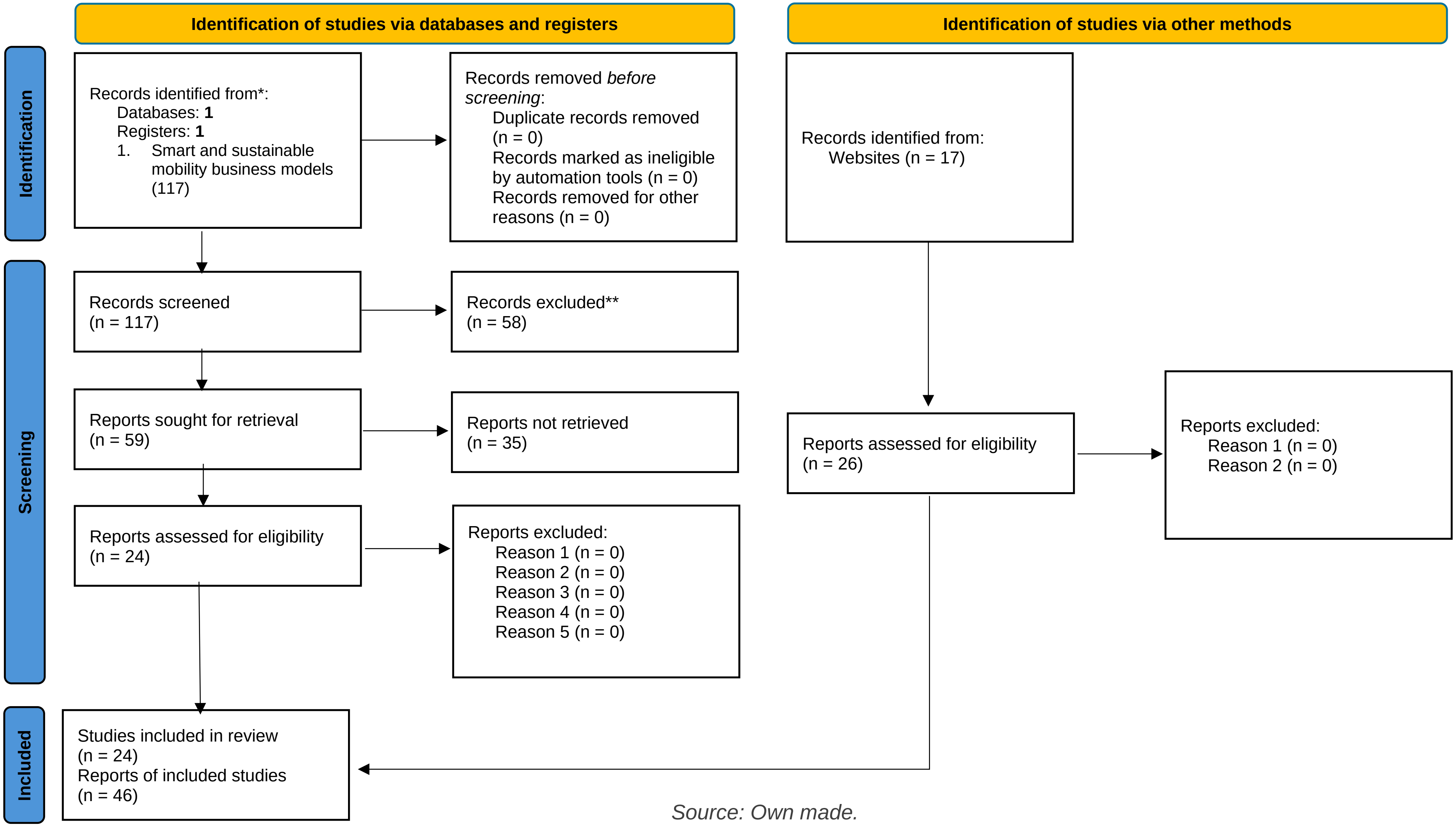
10. Anex.

Anex I: Sustainable Development Goals.

Source: (United Nations, 2024)

Annex II: PRISMA Diagram for Literature.



Source: Own made.

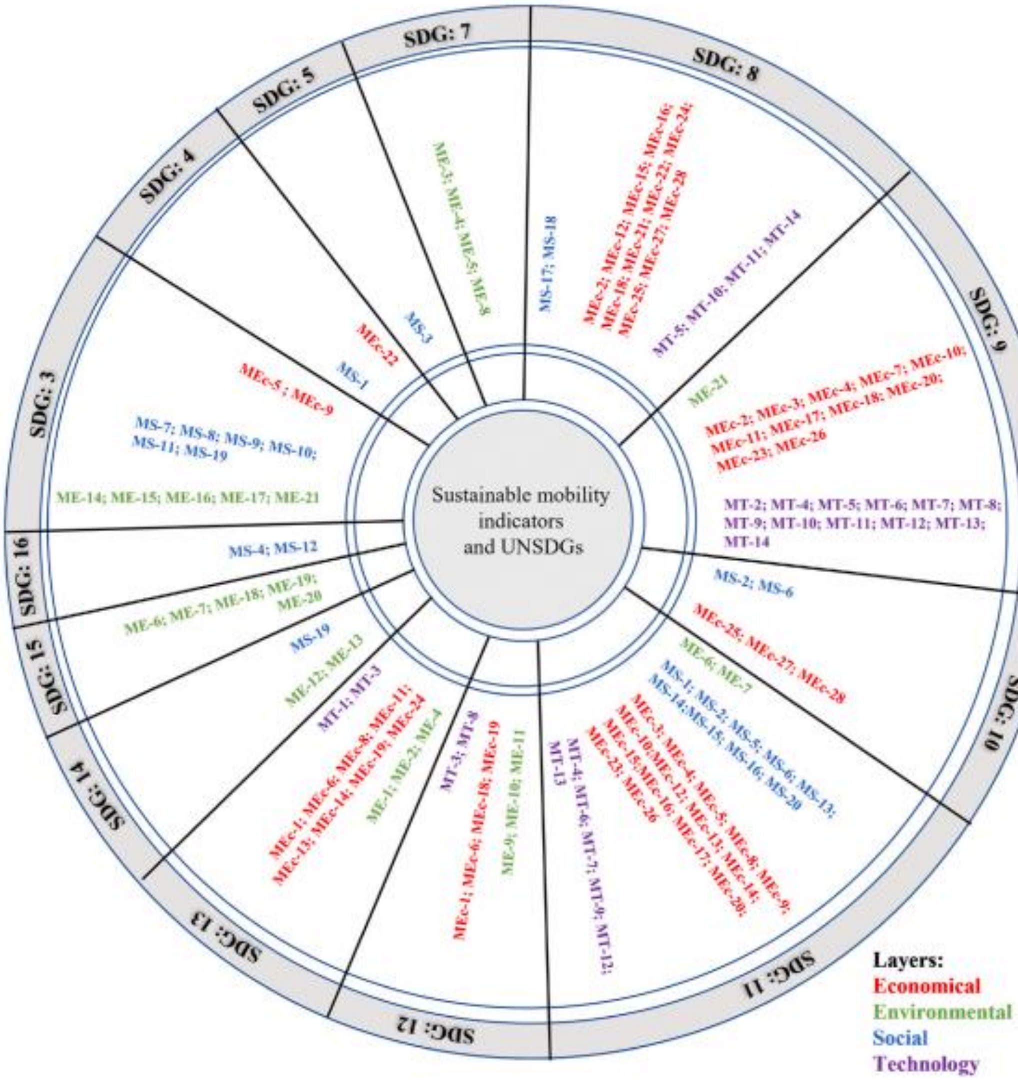
Anex III: Mobility KPIs associated with UN SDGs.

Indicators (KPIs)	ID
Preservation of cultural resources and traditions	MS-1
Responsiveness to traditional communities	MS-2
Gender equity	MS-3
Public participation in decision-making (the degree to which the public influences decisions)	MS-4
Signposting of different facilities and services	MS-5
Portion of destinations accessible by people with disabilities	MS-6
Number of traffic accidents (per km)	MS-7
Vulnerable road user accidents	MS-8
Number of fatalities and injuries (per km)	MS-9
Response time to emergency	MS-10
Safety on board	MS-11
Number of crimes committed on or while waiting for public transport	MS-12
Accessibility to terminals/vehicle stops from work/home	MS-13
Number of stations/stops	MS-14
Accessibility to essential services	MS-15
Availability of pick-up places (Micro mobility)	MS-16
Transport system diversity	MS-17
Punctuality (measured with an average of delay times)	MS-18
Daily average time budget	MS-19
Human exposure to particulate emissions and microplastics	MS-20
Portion of travel by healthy transport modes (walking/cycling)	MS-21
CO2 emissions	ME-1
Other GHG emissions (CH4, N2O, HFC, eg.)	ME-2
Clean energy use	ME-3
Fossil fuel consumption	ME-4
Non-fossil fuel consumption	ME-5
Promotion and policies of land-use	ME-6
Land use mix	ME-7
Transport system energy use per capita	ME-8
Tonnes of materials used for vehicles & infrastructure	ME-9
Recyclable/re-useable materials of vehicle	ME-10
Transport related wastes	ME-11
Vehicle water pollutants (exhaust, dirt, oil, deicing chemicals) deposited on surface areas	ME-12
Management of used oil, leaks, and stormwater	ME-13
Particle pollution	ME-14
Air pollutants (O3, CO, SOx, NOx, Pb, VOCs)	ME-15
Level of noise from urban transport	ME-16
% Population exposed to transport-related noise >55 dB	ME-17
Light pollution (Lumen)	ME-18
Loss of wetlands/agricultural lands/deforestation	ME-19
Number of wildlife/animal collisions	ME-20
Hazardous materials incidents	ME-21
Per capita fuel consumption	Mec-1

Efficient pricing (road, parking, insurance, fuel, etc).	Mec-2
Public transport investment expenditure in % of GDP	Mec-3
Overall road quality (Satisfaction with road system condition)	Mec-4
Length of cycling and walking paths	Mec-5
Old vehicles still in use (average age of vehicles)	Mec-6
Road network expenditure in % of GDP	Mec-7
Motorized traffic volume	Mec-8
Number of cycling trips	Mec-9
Modal share of public transport	Mec-10
Percentage of freight transported by road	Mec-11
Average commuting/In-vehicle travel time	Mec-12
Average commuting/In-vehicle speed	Mec-13
Average commuting distance	Mec-14
Delays due to congestion/Dwell time	Mec-15
Occupancy rate/availability of seating (Crowding)	Mec-16
Network capacity of vehicles, terminals & stops	Mec-17
Total operating & maintenance costs	Mec-18
Total environmental costs	Mec-19
Total public service costs	Mec-20
Promotion of career opportunities/creation of jobs	Mec-21
Affordable access to education and employment opportunities	Mec-22
Public response to a transit system	Mec-23
Social/External cost of transport	Mec-24
Total travel cost (affordability of monthly travel expense)	Mec-25
Availability and quality of affordable modes (walking, cycling, ridesharing, and public transport)	Mec-26
Portion of low-income households that spend more than 20% of their budgets on transport	Mec-27
Annual average household expenditure for urban mobility (per person)	Mec-28
Number of studies on environmental impacts	MT-1
How technologically advanced & mature is the system?	MT-2
Number of vehicles in operation at any given time	MT-3
Frequency of vehicles (service)	MT-4
Operating hours	MT-5
Annual number of passengers	MT-6
Annual number of trips	MT-7
Ratio of non-working vehicles at any given time	MT-8
Quality of public transport	MT-9
Electronic fare payment option	MT-10
Convenience of the vehicle schedules	MT-11
Overall Satisfaction with the service	MT-12
Availability & Accessibility of real-time travel information	MT-13
Ease of ticket purchasing	MT-14

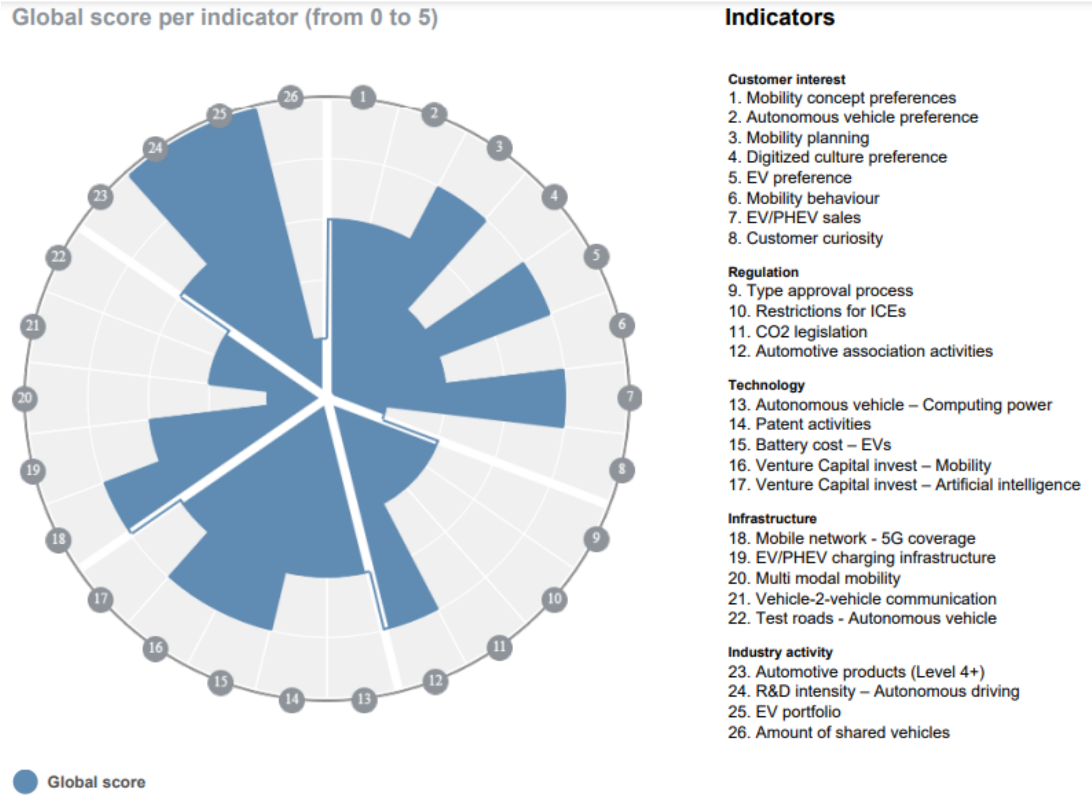
Source: Own made based on information extracted from Hussain et al. *(2023)*

Anex IV: Sustainable Development Goals.



Source: Hussain et al. (2023)

Anex V: Roland Berger's Automotive Disruption Radar.



Source: (Roland Berger GmbH, n.d.)